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A GEOGRAPHICAL INTRODUCTION TO THE HISTORY OF CENTRAL ASIA

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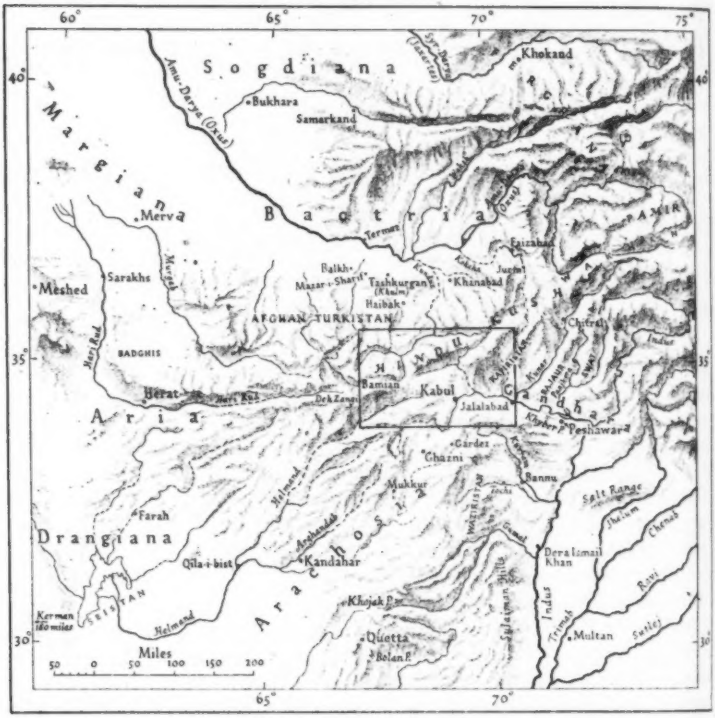
Continuation of a paper from the July–August Journal

THE high-altitude Hindu Kush passes leading into the Kunduz and Ghorband valleys are not the only gateways to India. The history of the Saka invasion of India *via* Seistan demonstrates the importance of the southern routes, which are accessible from the north, once the low-level Sarakhs–Herat gate has been forced. Southward the ancient trade-routes from Baghdad, *via* Isfahan or Shiraz, to Kerman, and so forking to Kandahar and the Bolan Pass, provided an easy and well-organized high-road to India. Nor can Alexander's homeward routes through Gedrosia and *via* the Persian Gulf be forgotten.

In discussing the trade of Asia, perhaps because of the barbarian invasions or of the romance of Alexander, there is a tendency to diminish the importance of the sea-routes; they were however well established, as the history of the Gerhans, the Phoenicians of the East, and of Antiochus III's wars with them, proves. The records make it plain that from very early times the northern Iranian route, the ancient Royal Road, from Tehran to Meshed, found its natural continuation to India, *via* Farah and Kandahar, so turning the gates of Hindu Kush and joining up with the southern Kerman routes. The Gedrosian road led, as it does to-day, through the Quetta valley and the Bolan Pass to the cities of the lower Indus and the great central market of Multan. From Kandahar there is a choice of two groups of routes, the first centred upon the Gumal leading to the markets of Dera Ismail Khan, the second upon the Tochi leading to Bannu, the site of the ancient Akra, and so to the markets north of the Salt Range.

Professor V. Minorsky has recently greatly furthered our knowledge of these regions by the learned notes he has added to his translation of the 'Hudud al 'Alam,' written by an anonymous geographer, who presented his work to the Amir of Guzganan in A.D. 982–3. For him, and he was obviously an inhabitant of what is now Northern Afghanistan, the country had four approaches. All Transoxiana, Ferghana, and Khorasan, and especially the

town of Gurgan in Khwarazm, were gates to Turkistan. Of all the available roads, the Merv–Balkh road, at that time, alone was "the Royal Road." Where it ended among the high mountains, somewhere in the region of Wakhan, was the gate of Tibet; while the gates of India were Bust,[1] the modern Qila-i-bist, where the Arghandab joins the Helmand, and Parwan, at the foot of the ravine and pass of the same name leading down from Hindu Kush to the Ghorband valley, opposite modern Charikar.



The rectangle represents the area covered by the map facing p. 31 of the July–August Journal

Alexander preferred the third available route to India, *via* Kandahar, Ghazni, and the Kabul valley. Kandahar is separated from the Quetta plateau and the Bolan by the Khojak ravine. The Kandahar–Ghazni–Kabul road is open. Moreover between Charikar and Parwan the Ghorband is bridgeable. From Charikar the Indian road follows the left bank of the united Ghorband-Panjshir straight to Jalalabad. At Begram there is a ferry, guarded by the ruined forts where Hackin found his treasure, and a little lower down there is one of several low-water fords. Thus at the Charikar bridgehead two main

[1] Bust was important under the Ghaznavi dynasty (A.D. 997–1040) as the remains of the fine mosque show (*Bull. Amer. Inst. Persian Art*, vol. 4, No. 1).

systems of communication unite, the dramatically direct routes from the Oxus Royal Road, *via* the high passes of Hindu Kush, and the roundabout, low-level, open road, *via* Farah, Kandahar, and Ghazni. Beyond Jalalabad a choice of easy passes leads through Bajaur to the Peshawar plain and its ancient cities, of which Pushkalavati, the Peukelaotis of the Greeks, modern Charsada, was the most important. This was the route adopted by Alexander for his main body. Its popularity survived until Mughal times; but it is noteworthy that the existence of Graeco-Buddhist remains in the Khyber indicates a fair antiquity for that route also. In the upper Kurram valley there are no archaeological remains. Huen Tsang passed through this region on his way southward to Varana. He describes it as being mountainous and thickly forested.[1] It was not until the days of the Mongols that the gate of the Kurram became notorious.

This cursory summary demonstrates a remarkable gap in the communications system of the Hindu Kush region, as we know it from the various literary accounts. It is interesting that we have no record of direct, east and west, contact between famous Bamian and still more famous Herat, although only the twin head-waters of the Hari Rud and the open downs of Deh Zangi intervene. The Emperor Babar once adventured in this direction in the depth of winter,[2] and Ferrier found his way southward across it, but none of the geographers, classical, Arabic, or Persian, mention it. On the southern slopes of the mountains to the south of the Hari Rud, forested areas still exist and, even in the valleys north of Bamian, there are remnants of coniferous woods. Since the gentian still flourishes on the stony downs of the intervening wind-swept plateau, it is possible that they were, also, once wooded. On the other hand, the area has more than once been identified as sociologically primitive, a backwater of peoples. In Istakhri, neighbouring Ghor is called "the country of the unbelievers," and Ferrier, a hundred years ago, found remnants of pagan worship among the Hazaras.[3]

It is not easy to account for Alexander's choice of the southward route to India, in view of the decision and energy with which he organized his expedition into Oxiana once he had arrived in the Kabul valley. If this had been his set purpose all the time, it would seem probable that he was deterred at Herat by rumours of tribal opposition, or it is possible, in view of Quintus Curtius' statement, that his intelligence service failed to obtain information as to the stages immediately east of Herat, along the line of march, which eventually became the Royal Road to Balkh. It is significant that the Bactrian upstart, Euthydemus, was able to hold up Antiochus III's advance into Bactria for a considerable time at Herat. The evidence suggests that it was the Bactrian Greeks who opened up the north and south passes of Hindu Kush in their first imperialistic expansion towards the Kabul valley and India. The victorious rise of the Sakas later made the crest of the great ridge a political boundary, which survived when Oxiana was lost to the Greeks. Hindu Kush, too, not the Oxus, is the southern boundary of Turan to-day. South of it Turki is heard only on the roads or in the *sarais*.

[1] Julien, 'Mémoires,' vol. II, p. 184; Beal, 'Life of Hiuen-Tsiang,' p. 193.
[2] Beveridge, vol. I, p. 308.
[3] 'Hudud al 'Alam,' p. 343; Ferrier, 'Caravan journeys,' p. 231.

It is commonly assumed that river valleys form easy means of communication, but a survey of Hindu Kush indicates clearly enough that this is not always so. Afghanistan is a mountainous country, sparsely threaded by river valleys of incredible richness. Humanly speaking, it is understandable that such valleys, oases of intensive cultivation in the wilderness of rocky heights, should tend to develop individuality, showing organized resistance to outside pressure. The right of taking toll upon passing traffic is universal in the East, and, from the merchant's point of view, has always exerted a strong influence upon the choice of available routes. But the rejection of valley routes is also explicable on purely physical grounds. Many of these valleys are blocked by gorges; many of them are steep and their rivers torrential. The snow lies here at 6000 feet from December to March, and, even when the night temperatures are low, the day temperature curves rise steeply; at 10,000 feet and over, the snow softens under the sun's first rays, causing marked diurnal fluctuations in the volume of the streams. Moreover the summer temperature culminates at the end of July, and in August the season of thunderstorms begins, leading immediately into the rains of October and the first snow-falls of winter. Schomberg has graphically described the difficulties of travel under these conditions. They are avoided only by low-level routes cutting across the lines of the main rivers. It will be found that the alignment of these depends, not only upon the availability of fords, but also on the state of the water at various times of the year; so that, for instance, even the Herat–Farah–Kandahar main road is duplicated and triplicated upstream, where practicable fords are still available, even in the flood season.

The early existence of bridges in Central Asia is clearly indicated, though it is seldom possible to define their position with any certainty. In the Himalaya and farther eastward swing-bridges and rope-and-pulley traverses are used, but these do not extend into Hindu Kush. At the village of Saddo, on the left bank of the Panjkora river, on the Chitral road, a Kharoshti inscription records the building of a bridge in the 104th year of a debatable era.[1] In southern Persia there are plentiful remains of rubble-masonry bridges, dating from early Sassanian times; while later burnt brick came into use, as in the fine Surkh Ab bridge on the Jalalabad–Kabul road, which was built by Ali Mardan Khan in Shah Jahan's reign. In Afghanistan there is also the finely constructed brick bridge across the Kokcha at Faizabad.

In the 'Pei Shi Ki,' an account of the Kin emperor's mission to Chengiz Khan, the observation is made that in Mussulman Central Asia bridges are built of large bricks, not of square stones as in China. The date is A.D. 1221, after Chengiz had constructed his military road *via* Bishbalik and Talas (Bretschneider, 'Mediaeval Researches,' vol. 1, p. 20). This road was later converted into a cart-road throughout its length. The Taoist Professor Ch'ang Ch'un, who visited Chengiz at Parwan in Afghanistan, travelled the whole way by cart, though it is clear that special arrangements had to be made for him. This road is said in the 'Si Yu Ki' to have been completed by Ogotai, the third son of Chengiz, probably in 1219, the Oxus still being served by a bridge of boats.

Apart from engineered bridges of rubble or brick, throughout Hindu Kush

[1] *Epigraphia Indica*, January, 1931, p. 23.

Approach to ferry across Ghorband river at Begram

Ferry across Ghorband river at Begram

Kunduz river, east of Bamian

Lower lake and Ziarat at Band-i-Amir, 44 miles west of Bamian

The two lower lakes at Band-i-Amir

and northward to the Chu and the Ili, the poplar, universally present as a planted tree throughout Central Asia, provides good bridging for spans of up to 40 feet or more, where the cantilever principle is used. But, whatever the material or technique, the volume and speed of the water at flood-level makes it essential that the bridge should be built as far upstream as possible. Below a certain point, fords, ferries, or occasionally boat-bridges, must carry the traffic.

The difficulty of travelling in such a country clearly does not lie in any want of routes. They are plentiful in all directions. In any sarai or tea-shop in the Ghorband valley, the local inhabitants will recite the names of a dozen passes leading northward across Hindu Kush or southward to Kabul. Historians are liable to be mesmerized by the names of historic routes and to write of the Khyber or the Bolan or the Khawak, or of the traditional Silk Route, as if they were established of necessity, without alternatives. On the contrary, Hindu Kush and Koh-i-Baba, like the Sulaiman hills, are plentifully supplied with tracks. The factors limiting the choice of route are however not only the calendar, or the availability of bridges, fords, or ferries. The lone traveller can take his choice freely, subject only to his ability to carry and replenish his own food stores. The donkey or pony rider is freer than the camel driver. The small caravan is freer than the large caravan, the outstanding consideration being not so much a question of rations for the men, as grazing for the beasts. Hence, certain routes are strictly seasonal, and transport is cheaper at certain times than at others, because the beasts are not weakened by dearth of fodder *en route*. But apart from the necessity of water and food for man and beast, the ever-present motive power of human convenience cannot be neglected as a major factor in the choice of routes. Small markets, as well as large, attract trade; goodwill of long standing is implicated. Personal relations in out-of-the-way corners, the existence of a *Ziarat*, or the residence of a *Pir*; that is of a shrine or a religious teacher; the happening of a feast or of a funeral, and even personal likes and dislikes, all bias the choice. Accidents, too, may intervene, as when the Zao Pass on the flanks of Kaisargarh was blocked by the fall of the Dabarrah rock, which still has a name and is spoken of. Taxation, always to be avoided by good business men, banditry of one kind or another, the existence of a single corrupt local official, or of one petty brigand, may cut the life-blood of trade from a route until the case is altered.

Since Afghanistan is a mountainous country, cultivable ground is at a premium, and the available water rights, without which the valley lands are dust and pebbles, set the standard of prosperity. Above on the hill-sides, wherever there is sufficient depth of soil, a scanty harvest of wheat or barley is snatched by means of the natural irrigation of the melting snows. It must be clearly understood that the Pathan way of life includes migration, but is not essentially migrant. The unit of the social structure is the tribe, established in grouped villages, the regional unit usually being the valley. The mode of action of this complex social machinery is republican and takes the form of village and tribal councils (*Jirghas*). That is to say, where land and water are sufficient, the social unit is well established locally and acknowledged land tenures persist. Indeed, ownership of land is, theoretically, a necessary qualification for the right to speak at the *Jirgha*. The Pathan is a

grower of upland corn and irrigated rice, but he is neither a gardener nor a fruit-grower. Where grazing is available, he keeps donkeys and camels, and, as with other peoples in similar surroundings, the necessity of keeping these alive all the year round has produced a kind of migration. So, in Elphinstone's day, the Miankhel migrated annually from Daman to the uplands of Shilgar, where, even in the heat of summer, grazing was plentiful. So to-day, many of the Jalalabad tribes migrate to the grazing grounds allocated to them on the downs of Koh-i-Baba by the Afghan Government, who, after repeated Hazara revolts, have thus nationalized these regions. The tribes travel with their families, their stock, and their tools, and are a major feature of the Afghan roads in spring and autumn. When on the road they are known as *Kuchis*, the marchers, and as such many of them take in their stride the dual boundaries of the Durand Line and the frontier of British India, where they spend the winter. Trade is superimposed upon the basically pastoral pattern of these upward and downward seasonal movements, the textiles of the Indian cities, especially the patterned Peshawri turbans, being prominent among the miscellaneous goods they deal in. The necessities and uncertainties of the road are reflected in their social organization. When professional merchants travel in the East, they do so under the leadership of an appointed *Kafila-bashi*. The tribes, when more than one family take the road together, appoint their *Chilwashti* or caravan-dictator, who, in spite of the realities of Pathan republicanism, holds absolute sway over the long drawn-out strings of camels and donkeys.

Since Afghanistan lies across the trade routes of India, China, and northern Persia, this profitable carrying trade has led to specialization on the part of certain tribes, the Lohanis being merchants in their own right and wholly mobile.[1] On the other hand, the retail trade of Afghanistan is, as a whole, not in Pathan hands. Just as he is not a gardener or an artificer, so the Pathan is not a shopkeeper. Throughout the Pathan hills, Hindu merchants live as protégés of the tribes (*Hamsaya*) and, even in modern Afghanistan, the retail textile trade of Kabul and Charikar largely remains in Sikh hands. Banking and the organization of credit was the monopoly of Hindu Banyas, until the institution of the National and Commercial Banks under the present dynasty. In spite of this modernization of the system under state control, the bankers of Peshawar, Bannu, Dera Ismail Khan, and Multan, still have their agents in the towns of the Oxus valley and even beyond, and until recently it was possible to obtain a reliable credit-note on Bukhara in any of the Indus cities. These Indian merchants did not own their own beasts of transport, but hired them on fixed contract rates from the mobile and semi-mobile tribes. It is therefore necessary to envisage Afghan tribalism, not as a thing apart, locked away in the fastnesses of the hills, but as closely linked with the polyglot, largely international, cities of the valleys and of the rich producer and consumer lands beyond, India, Persia, and Central Asia.

Since the Sakas belonged to the Iranian fringe, and made their way to India through Seistan by the ancient, southern, low-level route with the

[1] Vigne ('A personal narrative of a visit to Ghazni, Kabul, and Afghanistan,' 1843) travelled with a Lohani caravan, and gives a graphic account of their methods.

cooperation of the established Parthian government, it is necessary to consider the first historical impingement of Central Asia, nomadic Turan, upon the well-founded structure of Indo-Iranian political and commercial relations. In its initial stages Saka pressure destroyed Hellenistic Bactria, though it did not touch the Indo-Greek kingdoms south of Hindu Kush. Later these were overrun by the Saka–Parthian movement from the south. It was not until the first century A.D. that India had to meet the Kushan hordes, who, after destroying the Saka–Parthian satraps and the last remnants of the Greek kingdoms, set up an empire which straddled the great mountain divide and so created a new political unity, ranging from the Oxus to the Ganges. In doing so they created a new pattern in Indian history, for the White Huns in the fifth century and the Western Turks in the seventh followed in their steps.

Strabo twice states, categorically, that at the time of Alexander's invasion the Indus divided India from Iranian Ariana, the larger administrative unit, which supplanted the old Persian Arachosia.[1] Later, the Indians recovered a large part of Ariana from the Macedonians. This concise statement is amplified in his second passage: Alexander had deprived the Ariani of certain tracts west of the Indus and had founded settlements there, but Seleucus Nicator gave them up to the Indian king, Sandrocottus, as the result of a marriage agreement, receiving in return five hundred elephants. In this way, the Indians came to occupy in part some of the countries situated along the Indus, which formerly belonged to the Persians. The Ariani were Persians, since Strabo regarded the extension of Indian power westwards as an innovation. It is clear that Pliny, knowing all this, chose his words with care when he came to define the boundaries of India, for they had changed. He says: Most authorities do not accept the Indus as dividing India from the west, but add to it the four satrapies of Gedrosia, Arachosia, Aria, and Paropamisadae.[2] Since Sandrocottus is the Mauryan emperor Chandragupta, and Seleucus Nicator marched westward with his elephants to fight and win at Ipsus in 301 B.C., the history of the transaction, which set an eastward limit to Syrian ambitions in Asia, is well established. Strabo continues: The kings of Syria and Media being preoccupied, first occurred the revolt of the Bactrians, and later, with Euthydemus and his party, the revolt of all the country near that province. Through the fertility and advantages of the country, the Greeks became so powerful that they were able to make themselves masters of Ariana and India.[3]

In view of what happened later, this bald statement may be construed in terms of tribal resistance to the growing Bactrian power, stimulated by envy of its prosperity. Northward lay the intractable tribes of the Iranian fringe; southward the collapse of the Mauryan empire offered opportunities of expansion. To the west the power of Parthia was developing, and, although their kings called themselves Phil-Hellenes, their interest in the Indian and Central Asian trade routes dominated their practical policy, so that in fact their organization formed a solid wedge of self-interest between the Hellenistic west and the isolated Hellenism of Bactria. Arsaces, their leader, was a chief

[1] Strabo, XV, 1, 2, and XII, 2, 9.

[2] Pliny, *Hist. Nat.*, VI, 23.

[3] XI, 9, 2–3. Tirwhitt's conjecture, "MSS. at variance with each other," which is good sense.

of the nomad Parni, a branch of the Scythian Dahae, but their Scythian grossness was rapidly refined by the startling success of their conquests. Northward however the tribes of the barbarian periphery remained unchanged. Later their confederations increased in unity and consequently in power (Strabo, XI, 9, 3). Before Alexander's time the Dahae lay along the shores of the Caspian. To the east were the Massagetae and the Sakas. The Parthians arose from the same milieu and it was at the hand of the new Parthian power, firmly established in the classical heart of Iran, that the Bactrians, in the time of Eucratides (175–155 B.C.), first met defeat in their semi-Greek satrapies of Aspionus and Turuva. According to Strabo, Sogdiana was lost at the same time; that is to say, the tribes were already pressing southward to the Oxus. The first mention of Scythian pressure from the north is, perhaps, Polybius' record of Euthydemus of Bactria's plea in the days of Antiochus the Great's eastern expedition, shortly after 212 B.C. (XI, 34, 4). Antiochus was obviously concerned at Arsaces III's subjugation of Media; he had his eye on Parthia. Euthydemus set his own Scythian problem beside Antiochus' concern about the increasing power of Parthia. The truth would seem to be that the Greeks in Asia had never been united. Whatever Alexander had intended his empire to be, the personal ambitions of the Diadochi left no sense of brotherhood or national mission behind. Seleucus Nicator, in alliance with Diodotus I, had defeated the first Parthian attacks, but the Hellenistic alliance broke down. Diodotus II of Bactria was won over to an Asiatic policy and thus, consciously and effectively, contributed to the defeat of Seleucus II Euthydemus, who had forcibly supplanted Diodotus II, occupied Kabul about 200 B.C. From there he was able to extend his power southward to Arachosia (Kandahar) and then westward to Herat. It would seem that this western extension was not possible from Bactria, but only after the consolidation of his power over the southern trade routes by the refounding of Alexandria in Arachosia as a Hellenistic city. In creating this extensive empire the house of Euthydemus lost Bactria to the rebel Eucratides, and the rivalry of the descendants of the two houses may be traced throughout the history of the Indo-Greek kings. Demetrius, son of Euthydemus, seems to have been the actual conqueror of Ariana. According to Strabo, he and Menander were the pioneers of Bactrian Hellenism in India. Finally, the tribes of the periphery rose in their might and, unable to organize their extended lines of communication, Greek rule vanished for ever north of Hindu Kush. These tribes were the Asii, the Pasiani, the Tochari, and the Sacarauli, and they came from trans-Jaxartes, opposite the Sacae and the Sogdiani.

Strabo's statement that Demetrius conquered Ariana and won the title of "king of the Indians" would seem to suggest that Ariana was, at that time, Indian. In any case, he succeeded to Arachosia as well as to the Mauryan provinces round and about the upper Kabul valley. It is probable that when Aristobulus describes India as abounding in the oak, pitch-pine, and firs, he had the Kabul valley in his mind. Eratosthenes, also, says that firs grow in India and that Alexander built his ships of fir for his descent of the Indus. It is not until Ptolemy that continental India, the true, tropical India, became known to geography. For him, as for Pliny, the four adjoining satrapies of Gedrosia, Arachosia, Aria, and Paropamisadae, mark the limits of India,

ultimo fine Kophete fluvio, that is to say, up to the Kabul river where it flows into the united Ghorband-Panjshir at the very foot of Hindu Kush. But it is noteworthy that this expanded India was no longer autochthonous, but to a large extent under the dominion of foreign satraps. Through the whole period the control of the Kabul valley seems to have been dependent upon the mastery of Kandahar and the southern routes, not upon that of the Hindu Kush passes.

Apart from their coins, little is known of the India of the Greek princelings. Their sequence and distribution, as argued by Rapson and other numismatists, depends upon the acceptance of types and moneyers and regional symbols as historically significant. Very little is known of the distribution of the coins themselves, and arguments based on such boastful titles as ἀνίκητος and dolphin devices as indicating naval victories in the Punjab are not convincing. The joint Saka–Parthian invasion of India certainly split the Greek kingdoms in two and it is clear that Parthia later dominated the whole tract from Seistan to the Punjab.

Three dates however are of outstanding importance. Demetrius' intrusion from Bactria into India must have taken place about 190 B.C. About 170–175 B.C. Eucratides supplanted him. Shortly after 139 B.C. Mithradates I must have brought Bactria within the scope of the Parthian empire, for in that year Bactria aided Seleucus Nicator against the Parthians. Ptolemy gives little ground for the thesis that Greek cities survived as such in this region. Eucratides lost Herat and Arachosia to Parthia. The traditional "conquest" of India by Mithradates I (171–136) and the warlike activity of Mithradates II cannot be entirely without foundation, though it is doubtful how exacting their supervision of their Indian interests was. It is probable that they encouraged the Scytho-Parthian invasion of India which drove a wedge between the disunited Indo-Greek principalities. That Maues calls himself "King of Kings" is typical of the common failure of Oriental potentates to control their satraps. Later Gondopharnes boasts himself "αὐτοκράτωρ." The Periplus of the Erythrean Sea states that the Parthians were given to fighting among themselves. It was under these conditions, in the latter part of the first century B.C., that Indian influence once more dominated Arachosia and Gedrosia, as Ptolemy and Pliny knew. Indo-Greek numismatics also provide certain concrete data: Pantaleon and Agathocles are the first of these kings to use the Indian Brahmi script. Heliocles is the last king whose coins are found north of Hindu Kush. The coins of Apollodotus are found only south of Hindu Kush. Menander's coins are not found in Seistan or Arachosia.

On the other hand, the Hellenistic period of Indian history is archaeologically represented by three separate and distinct corpora of objects.[1] First, there are the Indo-Greek coins and a certain number of early intaglios and seals. These clearly demonstrate a process of Indianization. Second, many

[1] Sir John Marshall's views (*Arch. Sur. Rep.*, 1930, p. 151) are based upon his excavation of Sirkap. He attaches great importance to the Parthian period and to his analysis of Gandharan masonry. The Survey has since modified its treatment of the evidence, and it is now agreed that Gandharan sculpture owes its classical elements to late Roman influence.

sites in the Peshawar valley, as well as certain sites in the Ganges valley, have produced moulded terracottas of Hellenistic type, which date from the second and first centuries B.C. The technique itself is foreign to India and close parallels with Egyptian terracottas of the period can be made. Third, imported objects, including many bronzes of Roman or Alexandrian provenance, are found in the great city sites of the north-west and at Begram in the upper Kabul valley, and these show close contact with the Roman world in the first and second centuries A.D. At the same time, under the influence of this massive importation, representing the taste of the ruling classes of the merchant cities, the so-called Graeco-Buddhist art of Gandhara came into being. These imported objects include Roman bronzes of the first century A.D. and Syrian glass, which cannot be earlier than the second century. Their importation cannot be associated with the extension of Parthian power into India in the second and first centuries B.C., for none of the Roman objects are earlier than the second half of the first century A.D. Except for the Kurram valley, Graeco-Buddhist stupas and monasteries are found throughout the frontier hills from Swat to Waziristan, westward to Ghazni and Kabul, and northward to the Shibar, Bamian, and Kunduz in the Oxus valley. Under the Kushans, in the first and second centuries A.D., the Kabul valley, once again, belonged to India; their later, and lesser, successors long survived in Seistan under Sassanian influence and political control. It is noteworthy that Sassanian coins of the third century are common throughout the Kabul valley and north-western India to the Sutlej, indicating highly organized commercial, if not political, influence. Strangely enough, Sassanian influence was limited in the Oxus valley, where, from the time of the Kushans, pressure from Central Asia was constant. The 'Hudud records that Merv was Sassanian, Talaqan in Mervarudh being the easternmost frontier of the empire (pp. 332, 335, 337). It describes the ruins of the famous Nau-Behar at Balkh with its remains of fresco-paintings. These do not seem to have been known to Yacubi a century earlier, though he mentions the Balkh marshes and says that the city stood in the midst of sandy wastes. Sassanian antiquities have also been reported to the east of Balkh, at Khulm, but Marquart definitely proves that Sassanian rule only once extended to Balkh, and then only for a short time.[1] However Merv long survived as a firm buttress of the Iranian frontier, as did Herat, which accounts for the fact that the Kushan advance southward from Central Asia in the first century A.D. was deflected into Oxiana. The Sarakhs–Herat low-level route being blocked, the only way open for farther expansion southward lay across Hindu Kush.

Though the Sakas belonged to greater Iran, their advance southward into Bactria and India was motivated by pressure from Turan. Indian history knows of only three barbarian invasions B.C., leaving aside the Yavana Greek infiltration. The Pallavas of the texts are the Parthians and are represented archaeologically by such names as Vanones; the Sakas are the Scythians and are represented by Azes, Maues, Ranjubala, and Nahapana. With them must be grouped the Tukharas, who cannot be identified at all if they are not the Kushans. The suppression of all mention of the Kushans in Sanskrit literature is most interesting, but it cannot be used to prove that they were

[1] 'Eranshahr,' p. 47 *et seq.*

Scythians or the Tochari of Strabo. In the first century A.D. they and their confederates forced their way southward and were able to build an empire in India, which endured for at least five generations and witnessed the formulation of the Buddhist canon and the creation of Buddhist, Brahmin, and Jain iconography. The names of the Kushan kings indicate prolonged Iranian contacts. It has however been suggested that they were Turks by origin. As has been pointed out, the search for ethnic precision in Central Asia is always hazardous, but it can be said with confidence that the Kushans were not Huns, that is to say, Mongols. It is also clear that there was war and not peace in the tribal form of federal alliance, between them and the Sakas and the Wusun, with whom they came in contact on their way south.

The Chinese knew the barbarians of the Central Asian hinterland of old, and, like the Greeks and Scythians, they were concerned with them mainly as horse-riding, meat-eating, kumiss-drinking skin- and wool-clad barbarians. They had flocks and herds and camels, as well as horses, and, though they had no cities or fixed dwellings, each household had its settled grazing rights.[1] To the north-west were the Hiung-nu; to the east were the Tung-hu, who later played a prominent part as make-weight in Chinese balance-of-power politics.[2] As a defence against the hordes, the Tsin emperors built the Great Wall of China in the third century B.C. On the fall of that empire the Hiung-nu were able to extend their power from Lake Baikal to Jehol and southward to the cities of Kansu and Shansi. In the course of this wide expansion of power, they overran the Wusun in the region of Lop-nor and the Yüe-chi in western Kansu. In the time of their great tribal leader Mehteh (Meghder), at the end of the second century B.C., the Wusun had moved westward and were living south of Lake Balkash, while the Yüe-chi extended to the south-west of them up to the shores of the Caspian.[3] By the middle of the second century B.C. the threat of the Hiung-nu confederation was so considerable that the Chinese emperor Wu-ti sent the famous Chang-k'ien to the Yüe-chi to seek an alliance against the common enemy.[4] After ten years of captivity in the hands of the barbarians, he managed to complete his mission, but failed to convince the Yüe-chi of the value of Chinese aid. Eventually he returned to China in 125 B.C. bearing with him horses, alfalfa (the horse-grass), Central Asian grapes, and an accurate knowledge of the country between the Syr and the Amu Darya as far as Balkh. Meanwhile, the Hiung-nu power had fallen away before the first stirrings of Chinese imperialism, provoked by the barbarian threat to seek allies in the old Tungus group of peoples to the east. This time the alliance was successful, and the Hiung-nu, in their turn, were forced to migrate westward, where they played a prominent part in the Asiatic barbarian invasion of Europe. This western movement of the Hiung-nu under Chinese pressure was a defeat, but it was also a retreat in force, and brought about further movements of the mixed peoples west of Tien Shan, who were forcibly displaced. Of this Pan-Asian upheaval the Saka entry into Bactria

[1] On grazing rights: Parker, 'A thousand years of the Tartars,' p. 5.
[2] 'The heart of Asia,' Skrine and Ross, p. 14.
[3] Radloff, 'Concerning the Uigur,' p. 126.
[4] Chavannes, 'Sse-ma Ts'ien,' I, Introd., p. 89. Laufer, 'Sino-Iranica' throughout.

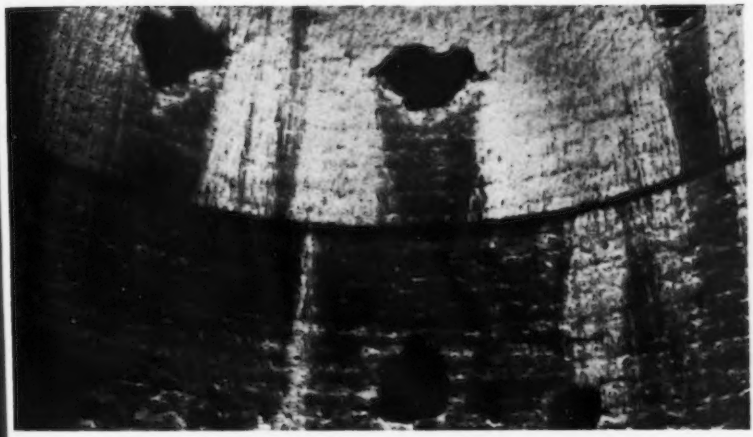
was an early symptom. The Yüe-chi having elbowed the Wusun out of the pastures of Issyk-kul, were pressing hard upon the Sakas to the south. The Sakas, in their turn, moved on into Bactria, but found no respite, for shortly afterward a temporary Wusun–Hiung-nu alliance forced the Yüe-chi to move still farther south. Eventually, in the rich Oxus territories, the latter were able to reform their political organization under five principalities so successfully that their influence stretched out along the trade routes to India, to which, like the Bactrian kings before them, they eventually shifted the centre of their rule.[1] The Kushans had the long sword, then a new weapon, which was later adopted and put to good use by the Sassanians. They also used scale armour, probably of leather, but there is no evidence that they brought the recurved bow to India.

The Chinese annals are curiously precise on certain points of this story, though all but the bare outline of the tribal inter-actions implicated remains obscure. In 125 B.C. the Yüe-chi to the north of the Oxus were nomads. They wandered with their flocks and herds between the confines of Parthia, Sogdiana, and Saka Oxiana. This statement would seem to confine them between the strong Parthian Merv–Herat line and the rich Oxus valley lands east of Termez and Balkh, then held by the Sakas. In Kansu they had numbered two hundred thousand bowmen and they had prospered since. The area must have been richer than it is now to support such a large population. As for the Sakas, they numbered over a million, but were socially primitive. They had no kings, each settlement being ruled by its own local chief. Their defeat was certain, and, after it was accomplished, among the fields and orchards of Oxiana, in close association with the subjugated Saka, the Yüe-chi inevitably abandoned nomadism for the more secure life of settled towns and villages. They penetrated the hills and occupied the upland valleys, eventually, under Kujula Kadphises, leader of the Kushan division of the tribe, spilling over the passes into the Kabul valley. Among the settled Sakas, who thus were absorbed into the Kushan empire, seem to have been the Asiani, whom Trogus Pompeius calls "kings of the Tochari."[2] In other words, the Kushan royal horde, when it finally emerged triumphant in the rich plain of India, was a mixture of peoples, regimented under one of the Yüe-chi families of the old Kansu regime. As has been said, the Mahabharata, which is ignorant of the family name Kushan, treats only of the Tukharas, brigading them with the Yavanas, the Saka, and the Pahlavas, the four historic foreign invaders of continental India. Tukharistan is traditionally the upper Oxus valley, the land where the Kushans first established their power in the old cities of the Sakas. It would seem that in India the regional name occluded the dynastic.

[1] This view is based upon Polybius and the writings of Foucher. It is supported by Barthold 'Le Royaume Grec de Bactriane et son extension' (Ac. de Pétrograd, 1916), and Von Sallet, 'Nachfolger.' It is not possible to look beyond the Scythian invasion of Bactria for any clear view of the state of the country and its inhabitants, though Strabo does say that the pre-Greek Bactrians were more civilized than the Sogdians, who lay between the Oxus and the Jaxartes.

[2] Justin, xxxiv, I, 4. Bachhofer, A.O.S., vol. 61, No. 4, p. 223, accepts the Chinese sources as contemporary, and on the strength of the Trogus passage identifies the Kushans with the Ariani. But the Chinese accounts are not consistent, and their dating is by no means clear, as Laufer constantly points out.

Lower courtyard, Shahr-i-Zohak



Interior of dome, lower courtyard, Shahr-i-Zohak

Arched chamber, Shahr-i-Zohak

Dome with squinch, Shahr-i-Zohak

A. Fresco from ruined dome with squinch, Bamian

B. Fresco, Fondukistan

C. Detail of fresco, Great

B. Fresco, Fondukistan

C. Detail of fresco, Great

The history of India remains obscure during the third and fourth centuries A.D. On the edge of India proper, Gandhara and its Buddhist monasteries prospered, and so did Sassanian Iran, up to the desert which divides Seistan from Baluchistan. At the beginning of the fourth century, stirrings of a new kind of nationalism in northern India brought into being the great Gupta empire, before which Kushan dominion crumbled, though it survived in the Kabul valley for a time, and persisted under Sassanian domination in Seistan. The last remnant of Kushan power in the north must have been swept away in the fifth century by the detachment of Ephthalites, who challenged and eventually destroyed the Guptas and maintained their own kings for two generations in Malwa. Known to the Arabs as Haytal and to the Chinese as Ye-tha, the Ephthalites, or White Huns, have been identified with the Hiung-nu. There is little evidence as to their origin, but it can be said that they were typical of the many intruders from Central Asia who are described in the Chinese annals, and that they advanced in two different directions, one body moving towards the Volga, the other towards the Oxus. The White Huns of the Oxus had no difficulty in reducing the decadent Sassanian kingdom to vassalage. All resistance ceased on the death of Firuz in A.D. 484. The Merv–Herat buttress had at last been shattered, and this crucial Sassanian failure inevitably let Turan into Oxiana and beyond. Nor was Hindu Kush a sufficient obstacle to stem the tide. Skandagupta, the Gupta king, had successfully repelled what seems to have been the first White Hun foray into India in 455.[1] They returned in force about the year 470, and this time were successful and stayed. Toramana, their leader, assumed the Indian style of *maharaja*, as three extant inscriptions show, but India was only a province of the Ephthalite empire, which seems to have been governed from Bamian. Bamian lies over 8000 feet up: it is snowbound in winter; the apricot and mulberry do not grow there. It is not the capital of a politically-minded people or the headquarters of wide-flung commercial interests. Nor would the Buddhists have congregated there if it had been thickly populated. Toramana was followed by Mihiragula, presumably the Golla of Cosmos Indicopleustes. The Indian accounts parallel Gibbon's summary of Hunnish characteristics. Mihiragula is repeatedly held up as a Buddhist iconoclast, and consequently the destruction of Gandhara is commonly ascribed to him. The significance of the dominance of the White Huns in the fifth and early sixth centuries is that under them for the first time all the trade routes, both northern and southern, Dzungarian as well as Kashgarian, were under the control of a single federation. This being so, the pepper which the Huns demanded as part of the booty of stricken Rome must have travelled from India by sea. As far as China and Byzantium were concerned, Turan held the trade of Asia to ransom. They failed however to keep what they had won. Their Indian detachment vanishes from history, though petty Ephthalite baronies survived in Hindu Kush, eventually to be absorbed in the victorious hosts of Islam.

Among the Ephthalites' temporary vassals, a power of a very different order was already waxing. The Turks proper, the Tu-kueh, were on the threshold

[1] Bhitari inscription, Fleet No. 13. Cunningham, *Arch. Rep.*, vol. I. "Sung-yun's travels," Beal, 'Records,' vol. I.

of history; that is to say, a new Central Asian federation under Turkish leadership was forming.

According to the Chinese annals, the Turks were of Hiung-nu descent, but that amounts to little more than that the Chinese historians knew them to be neither Chinese nor Iranian. Their clan name was Assena and, being dispossessed of their own lands by the Toba Tungus princes of northern China, they voluntarily became the vassals of the Juan-Juan, who were the enemies of the Tobas and dominated Central Asia from the land of the Kankalis (the High Carts) in the region of Baikal, to the borders of the legitimate Chinese government at Nanking. This was in the first half of the fifth century. Iron and the art of forging iron are referred to repeatedly in the Chinese records. Swords passed as currency and there are stories of swords received at the Imperial court as tribute from the Hiung-nu. Moreover Pliny, rather unexpectedly, includes iron among the exports from China to the West. It is recorded that the Juan-Juan employed the Turks as iron-smiths, but they appear chiefly as traders in silk fabrics and floss-silk for wadding in the Chinese annals of the fifth century. They must have prospered, for in A.D. 546 their leader was in a position to demand a Juan-Juan princess in marriage. The result was war and a complete victory for the Turks. Within a few years they ruled, not only from the Great Wall to the borders of Iran, but also in the far north, whence reports of snow-shoe hunting, dog-sledges, and the moose appear for the first time in the Chinese records. They were horsemen of the Central Asian tradition, armed with horn recurved bows, singing arrows, coats of chain-mail, and the long sword. Their use of the latter indicates Sassanian influence, not Chinese. Although they were nomads, yet, like the old Hiung-nu, each head of a household had his own definite grazing rights. They were not Buddhists but worshipped spirits. They could however write. Mukan, their second great Khakhan, was succeeded by Tapo in 572. His power was such that the Chou and Ts'i emperors gave him their princesses in marriage, together with tributes of fabulous quantities of silk. Unlike the impoverished skin- and wool-wearing barbarians with which the Chinese annals and the accounts of the Chinese pilgrims abound, the Turks were clothed in silk and feasted on flesh. Moreover they were appreciative of Buddhist propaganda. Tapo found a Buddhist teacher among his prisoners of war, and later built a monastery and sent to Honan, not to India, for Buddhist books.

Byzantine history confirms the contemporary records of Chinese diplomacy. Between A.D. 563 and 568 the Turks, in alliance with the Sassanian Khusru Anushirvan, overthrew the hated Ephthalites. The alliance was a pitiful fiction, for in reality the Turkish confederates were masters from the Don to the Great Wall. However the weakness of family jealousy, inherent in the Central Asian tribal system, once again made itself evident, and in 582 the great empire broke up. Even so, the western Turkish principalities, feudally interlinked by descent and diplomatic marriages, maintained a firm hold on the territory between the Syr and the Amu, and the rich valleys that lead down into it. They thus were able to control the great caravansarais of the Chinese trade, Samarkand, Paikind, Kist, and Bukhara, ruling through scions of the

royal blood, or even the surviving petty barons of the older Ephthalite, Kushan, and Iranian regimes. Huen Tsang passed through their domain in A.D. 630, and the passport they gave him ran from Issyk-kul to Bamian, the language, writing, administration, and money of which were all Turkish. He even says that the people of Bamian were Turkish in feature. Kapisa, too, across the great barrier, in the Kabul valley, was under Turkish influence. Its script was Turkish, but its language was different, and the people wore wool and furs, not silk. Huen Tsang says that the king of Kapisa was a Kshattriya, but that does not mean that he was an Indian. Indeed, he specifically calls the Black Mountains east of Kapisa the frontier of India. On his return, he had to modify this statement, for in the interval the Indian kingdom of Gandhara had collapsed, and the king of Kapisa ruled from Hindu Kush to the Indus. This marks the easternmost limit of Turkish power in India. The dynasty was eventually succeeded by, or, rather, merged into, that of the Shahi kings, who ruled at Kabul, but whose coins are plentiful right up to the Sutlej. The Shahis were, in their turn, succeeded by the Brahmin dynasty of Ohind on the Indus, who met its fate at the hands of Mahmud of Ghazni.

It is significant that the first eastward extension of Muslim power came through Seistan. That was in the days of the Caliph Othman and achieved little more than a military reconnaissance of what must have been the main trade route between India and Mesopotamia. To the north lay the Turks and, in point of fact, the final reduction of Central Afghanistan was delayed till the rise of Ghazni, and even then it is clear that the tribes proved recalcitrant. In A.D. 638 Yezdegird had ineffectually appealed to the Chinese court for aid against the rising power. He received a temporizing answer. It is astonishing that the Imperial Court should not have realized the scale and moment of the Muslim thrust. Even Huen Tsang, who must have heard talk of them, never mentions Islam or the Arabs. Yet the Muslim banners actually crossed the Oxus in 675–6, though it was not until 706 that Qutayba was able to establish Arab domination in Transoxiana. China, torn by internal dissension, was by then faced with a fresh source of barbarism, in Tibet. By the eighth century the Tibetans had come to dominate Taklamakan and the old channels of Asiatic trade were thus broken in two places.

Tabari, in a passage which is no more than a casual parenthesis, and is therefore quite unbiased, records the very end of the Turkish dominion. So few western historians recognize the size of Asia. They record Rome as bringing all nations under her sway and Napoleon as dominating the world; but due tribute is seldom paid to the tremendous events of Asiatic history. From Mehteh to the Turkish Khakhans, Asia knew organized empires that could only be challenged by Rome at her greatest. They were fugitive and passed away because the tribal system was in itself essentially unstable. Confederations are effective in action only under personal leadership. Leadership begets ambition and ambition destroys the loyalties that gave it its opportunity. The problem implicit in the history of the continent is still a real one, where the old tribal loyalties survive, and the historic difficulties of the task of governing under such conditions should be admitted in discussing the history of modern Iran or Afghanistan. The chief centre of resistance to Islam was not in the

great cities of the plain or in the rich valleys, but in the broken country on either side of the Oxus, from Chaganian to Badghis and Herat. Here descendants of the Turkish royal house still ruled and could command tribal allegiance in their highland valleys. They fought manfully a hopeless fight. In 710 two Turkish barons, who had already accepted Islam, are described by Tabari as paying homage to the defeated Turkish prince, admitting themselves loyal to the dying regime in the conqueror's presence.[1]

This rich chapter of history, wherein Turan breaks in upon Iran, and itself is overthrown by the Faith in whose eyes all men are theoretically equal, is recorded in a polyglot and voluminous literature, Chinese, Byzantine, Arabic, and Persian. But, as so often happens, all human values are lost in the stilted record of events. Fortunately there is plentiful archaeological evidence to enliven the pedantry, or propaganda, of the texts; indeed, the mass of material is so voluminous that it will be many years before it can be properly sifted and put to historical use. Central Asia not only has cities, but they have also been visited and described many times. Yet the Buddhist frescoes in Berlin, with their graphic representation of contemporary life, are only a fraction of the available evidence. Torn from their context and glazed in a museum, they do not represent in any way the mass of monuments which remain in situ, of which no adequate photographic record is yet available. No one site, no one building or cave has yet been recorded as a whole. Sir Aurel Stein's careful records remain our chief guide, and, even in his case, the objects brought back are divided between the British Museum and Delhi.

In all this mass of material three main periods can be distinguished on purely archaeological grounds, that is to say, allowing the objects to speak for themselves, without literary bias. The first is typified by Stein's Miran site, where Graeco-Buddhist influence from Gandhara appears, almost unaltered, in association with a plentiful supply of dated manuscripts, inscribed in the years between A.D. 263 and A.D. 330.[2] The second is represented by le Coq's north Taklamakan cave- and temple-sites, with their magnificent display of frescoes. In these paintings le Coq rightly distinguishes the Kizil knights of the lapelled coats and long swords, as portraits of donors, representing the ruling society of the day. The third period is that of the Tibetan domination of the eighth century, in which the origins of the familiar Lamaistic Buddhist art of modern Tibet and Mongolia may be clearly traced.

Le Coq failed to distinguish the period of the Kizil knights from the period of Tibetan dominance, which followed it; but new evidence from Afghanistan forces a revision of his treatment of the facts. For accurate representations of the very same knights occur at Bamian and at Fondukistan in the valley of that name, which opens into the Ghorband east of the Shibar Pass, a graphic illustration of the length and breadth of the Turkish empire.

At Bamian they appear in conjunction with late Graeco-Buddhist iconography and with certain, very distinctive, domed chambers with arched squinches cut in the rock. At the nearby ancient fort of Shahr-i-Zohak the

[1] Gibb, 'Arab conquests,' p. 9.

[2] It is not intended to discuss the dating of Gandhara sculpture here, nor to deal with the archaeological facts in detail, which will be treated at greater length elsewhere.

originals of the Bamian caves are to be seen, built four-square, in finely burnt brick, demonstrating the functional purpose of the arched squinches. At Haibak there is another exactly similar cave, while at Kunduz there are the remains of a brick building on identically the same plan. Lastly, the early French excavations at Kabul, itself, unearthed a similar brick building, the discovery of which is however only recorded in a footnote. The Shahr-i-Zohak domes in fine brick differ utterly from the early Sassanian rubble domes, though their arched squinches later appear in the many *Chahar-Taqs* of southern Iran, some of which were fire-temples, but which are generally agreed to be late Sassanian. Masson's find of fifth-century coins at Graeco-Buddhist Hadda has been confirmed by Hackin; while the frescoes and terra-cottas of Fondukistan, where the donors wear the costume of the Kizil knights, show clear Chinese influence. Artistic accomplishment of this order, based on such wide-flung contacts and, indeed, the patronage without which it could not have been born, can only be attributed to the Western Turks, the silk-clad lords of the Silk Route. The Ephthalites were incapable of such work, and once Islam had straddled the Oxus, it was impossible. Subject to a detailed re-survey of le Coq's, Stein's, and Pelliot's material, with all its problems of earlier and later Buddhism, Manichaeism, Nestorian Christianity, and Tibetan Lamaism, it may be suggested that Bamian was new when Huen Tsang saw it and that from Kizil to Kabul, these monuments must be dated *circa* A.D. 570–630. Furthermore, it is possible that the Kunduz, Kabul, and Shahr-i-Zohak squinched domes are the earliest of their kind known. In any case, Shahr-i-Zohak must be regarded as a site of the very greatest importance.

Ibn-al-Athir mentions the Afghans under the year A.D. 976–7. The 'Hudud records them as inhabitants of Saul, which is listed between Gardez, specified as being the frontier town between Ghazni and India, and Ningnahar, the modern Jalalabad, whose king, the author says, made some show of being a Muslim, and had Muslim, Hindu, and Afghan wives. Mahmud enlisted Afghans in his army, but, even in those days, it appears, the Pathan tribal individualism was active, for both he and Sabaktegin sent punitive expeditions against them, as indeed the Emperor Babar did five centuries later. They seem to have been confined to the region of the Sulaiman mountains, for there is no record of them west of the Ghazni–Kandahar road or in the Kabul valley. Indian historians strangely distort their sources when they call the Tajik Ghuris and the Turkish Khiljis Afghans. Indeed, the tribesmen themselves have consistently rejected the name Afghan, preferring the federal title of Pathan. As such, they early won renown as mercenary soldiers throughout Persia and northern India. As mercenaries, side by side with their fellow mountaineers, the Kurds, they served Nadir Shah and were with him at the sack of Delhi. Nadir Shah's death left a vacuum in Asia. It was filled, in these parts, by the rise of modern Afghanistan.

In 1747 Ahmad Shah Abdali was crowned with the willow by the common consent of the Pathan tribes, acting in conjunction with the Tajik and Hazara leaders. In 1929, after the suppression of the rebel, Bacha Sakau, His late Majesty King Nadir Shah was proclaimed king by general acclamation. Between these dates, the Turkomen of Oxiana, the Hazaras, and the Nuris of

primitive Kafiristan have been unified under the Kabul government. The historian has to record nothing less than the making of a nation.

Afghanistan exists to-day as an independent country between Russia and British India. Its boundaries were demarcated by treaty. Holditch, to whom we owe the greater part of our knowledge of its geography, was personally concerned, as an official, with the problems of demarcation, diplomatic and strategic, as well as cartographical. His work was directed to practical issues, on which he held the opinions of his day. He writes with confident authority, reflecting the almost dogmatic objectivity of nineteenth-century politico-geographical theory, fortified by the imposing bibliography of the Ratzelian school. In spite of Vidal de la Blache, Febvre, and Henri Berr, it is still hard to avoid the delusive simplicity of the argument, with all its assumptions:

Races and areas are to be studied comparatively; where differences in men are discernible, they are due to difference of race; where likenesses are found, they are due to environmental necessity. So it comes to be that Central Asia *is* nomadic. Its steppes and deserts of necessity produce nomad tribes, who sack and pillage the rich lands of their politer neighbours, because it is their nature to do so. Anybody who does this sort of thing is a nomad. Peisker, in his brilliant contribution to the 'Cambridge Mediaeval History,'[1] specifically speaks of "the identical origin of all the mounted nomads of historic and modern times." They are the product of "the Oriental background." "Spanish and Italian nomad-shepherds, too," he says, "can have no other origin." Miss Semple, again, stressing the necessities of the Ratzelian environment, writes of "the powerful effects of the dry and stimulating air of the steppes as inducing the migratory habit"; while Huntingdon finds an entire solution of the complex problems of Central Asian history in dessication. To-day we may, perhaps, be allowed to admit that we have no single universal key to life's questions. At any rate, we must abandon the verbal *deus ex machina*, and be content to define our terms as we learn our facts. There is still much research to be done, if misunderstanding is to be avoided.

Central Asia is now united as it has never been before. The strategic railways of Imperial Russia have been put to real economic use, so that Sinkiang, the ancient high-road, is now a back-water, ringed around by the railways which serve the Asiatic Soviets. Since the central government revised its policy towards religions, it is commonly admitted that the organization of the trans-Oxus Soviets has been successful. Afghanistan, lying between Russia and British India, is naturally interested in what is being done in both countries, and, since the Pathan Tribal Agencies lie between the Durand Line and the actual frontier of British India, ranking as British protected territories, especial interest is taken in Indian politics. The maintenance of this Afghan irredenta remains a major problem, for its peoples are solidly Pathan by race, speech, and traditions. Afghanistan is solidly Muslim, and as an orthodox Muslim state can only be compared with Saudi Arabia, having little interest in common with Shiah Iran or heterodox, polyglot India. Now that the Iran railway provides a north and south link between Asiatic Russia and the Persian Gulf, it is unlikely that the capital cost of extending the existing Russian rail-head to Quetta, *via* Herat and Kandahar, will be considered

[1] Vol. I, p. 358.

worth while. Meanwhile, the policy of the Afghan Government is based upon the determination to develop the resources of the country and so, step by step, to raise the standard of living of the people. It is generally admitted that the process must be slow, but it is felt that a great deal can be done with the friendly cooperation of the neighbouring states.

DISCUSSION

Before the paper the PRESIDENT (The Rt. Hon. Sir GEORGE CLERK) said: Mr. Codrington, who has been since 1935 Keeper of the Indian Section of the Victoria and Albert Museum, has had a varied and distinguished career in the Indian Army, and at both Oxford and Cambridge; more recently he has been on a long expedition to Afghanistan. To-night he will give us his geographical results, and, I hope, something of the archaeology which, as we have learned from a very great man and a lamented friend of the Society, Monsieur Hackin, and, more recently, from the Asia Lecture by Mr. Evert Barger, has such singular importance in the study of the development of what we are pleased to call the human race.

Mr. Codrington then delivered the lecture printed above, and a discussion followed.

Mr. R. M. S. MORRISON: I have listened with the greatest pleasure to the most excellent paper by Mr. Codrington, who I can assure you not only knows Afghanistan intimately, but is also extremely well favoured by the Afghans themselves, to such an extent that there must be many who may envy the high esteem in which he is held by all classes in that country.

I do not pretend to be a student of archaeology, although my travels have frequently brought me into touch with those who engage in this study, but I know that Mr. Codrington besides being an archaeologist is also much more, but these are things which perhaps in this Royal Geographical Society he is not able to tell you all about now. In thanking Mr. Codrington for his extremely interesting paper I can do no less than assure you that we have really heard something of considerable interest concerning a land so few Europeans visit from one who is indeed a master of his subject.

The PRESIDENT: Mr. Morrison has just stated that we have heard something from a master. That is obviously true. It would be hopeless to try to comment on a lecture so packed with knowledge and learning and expert research.

The light Mr. Codrington has thrown upon the tremendous problem of the cradle of civilization may to him only be a glimmer; to us perhaps it is little more than a rushlight. But it is in work such as he and others like him carry out that we find we can, from little indications here and there, build up a picture of civilization of which we have previously had no idea. Such papers as Mr. Codrington's paper carry with them the traces of absolute truth. It is on those lines that, after the war, I see a future for us and the work this Society does.

That is all the more reason why we should be especially grateful to Mr. Codrington for the paper he has given us. I hope that when we reach happier times he will continue to work on the great projects which he has shown us this evening and that the day will come when we shall have another and, if possible, even more interesting paper from him.

NOTES ON THE RHINE DISTRIBUTARIES AND LAND RECLAMATION IN THE NETHERLANDS

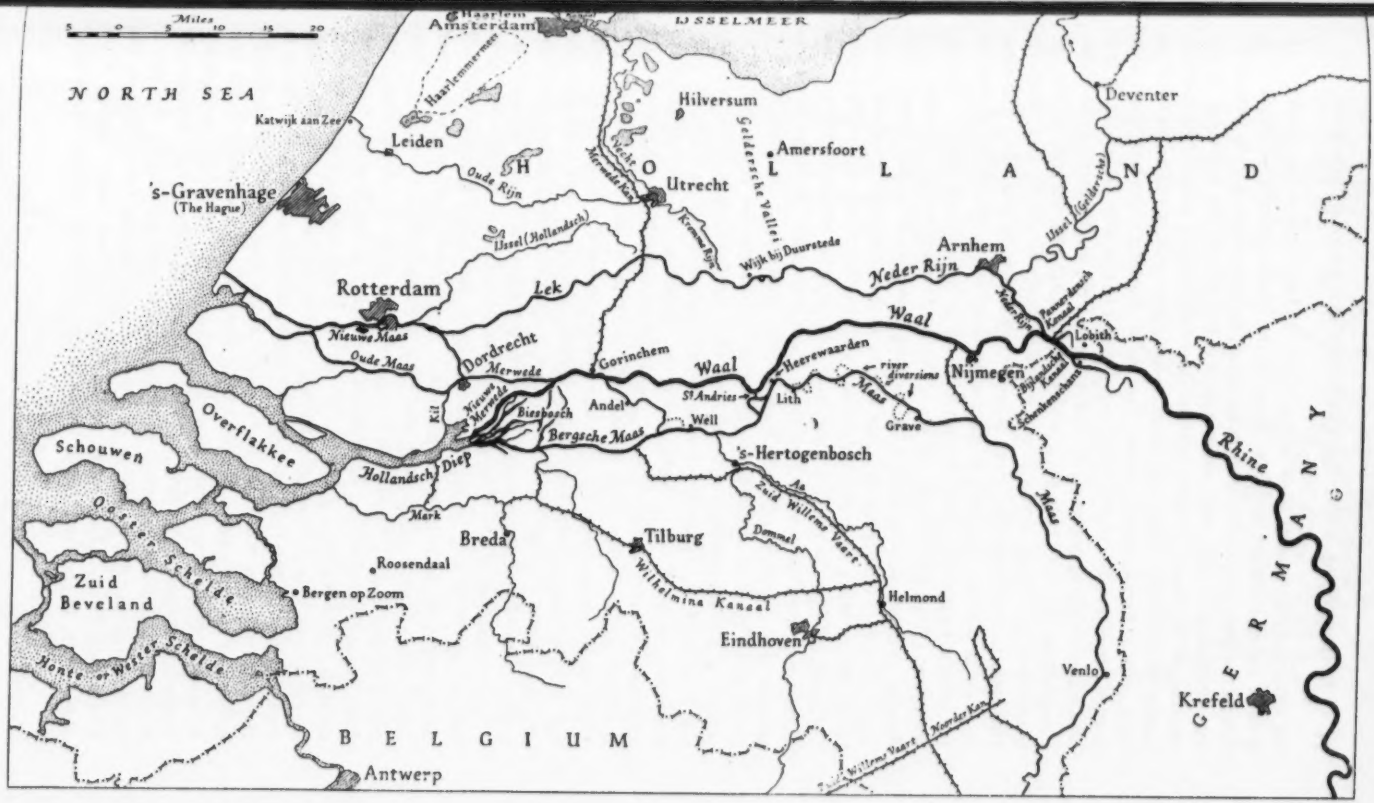
G. R. CRONE

THE waters of the Rhine now reach the sea through three distributaries of varying importance, the Geldersche Ijssel, the Neder Rijn, and the Waal. Of the volume of the undivided Rhine above Lobith, approximately one-ninth flows down the Ijssel to the Ijsselmeer (formerly the Zuider Zee), two-ninths down the Neder Rijn, and two-thirds down the Waal. As evidence of the changing history of the hydrographic system, the two latter distributaries bear various names on certain stretches of their lower courses. Below Wijk bij Duurstede the Neder Rijn is known as the Lek, and this in turn as the Nieuwe Maas. The Waal below Gorinchem is known as the Merwede, and formerly some of its waters reached the Nieuwe Maas through the Oude Maas. Its main discharge is through the Nieuwe Merwede to the Hollandsch Diep, so that it is this estuary which now receives the bulk of the Rhine water.

The present situation results from a combination of natural tendencies and control measures executed by the Dutch. Throughout there has been a marked tendency for the discharge through the south-westerly mouths to increase at the expense of the more northerly. In recent geological times there were two main Rhine exits, one to the east occupying approximately the present course of the Ijssel, and a western branch down a cut in the Veluwe glacial deposits, now known as the Geldersche Vallei. By the Roman period this section had been abandoned, and the main exit had developed farther westwards. Its course is marked by the Kromme Rijn, which leaves the Neder Rijn at Wijk and meanders to the neighbourhood of Utrecht, where it splits into the Vecht, continuing northwards, and the Oude Rijn, which enters the sea at Katwijk. To-day no Rhine water, except small quantities in times of floods on the main river, passes through these canalized rivers to the sea. The cause of this decline is largely related to developments in the Lek and Waal, which are explained by the physical history of the littoral as a whole. These two branches existed at an early period, but their importance was much less than it now is.

The great diluvial delta of the Rhine falls steadily from south-east to north-west. Over its surface the rivers have deposited great quantities of river gravels and clays, with finer sands and mud around their mouths. The outer margins were formed by expanses of low peat, fringed by a protecting belt of dunes. Before historical times, this area, traversed in the north by channels from the forerunner of the Zuider Zee and in the south-west by numerous estuaries, was a low maritime plain largely submerged at high tides.

Upon reaching the delta, the Rhine loses much of its velocity and splits up into numerous winding arms, which, while uncontrolled, frequently changed their courses. They also deposit much of their load, thus raising their beds and during flood building up natural levées along their banks. Relatively slight changes in the general conditions thus have considerable effects. The dominating influence is the tidal regime along the coast. In the south-west


Miles
5 0 5 10 15 20
NORTH SEA
IJSSELMEER
Amsterdam
Haarlem
Haarlemmermeer
Katwijk aan Zee
Leiden
Hilversum
Amersfoort
Deventer
's-Gravenhage
(The Hague)
Oude Rijn
Utrecht
Vecht
Merwede Kanal
Geldersche Vallei
Kromme Rijn
Wijk bij Duurstede
Arnhem
Neder Rijn
IJssel (Geldersche)
IJssel (Hollandsch)
Rotterdam
Lek
Waal
Nieuwe Maas
Oude Maas
Dordrecht
Merwede
Gorinchem
Heerewaarden
river diversions
Nijmegen
Lobith
Pannerdensch Kanaal
Nederrijn
Amsterdam-Rijn Kanaal
Schoonhovensche
Nieuwe Merwede
Kil
Biesbosch
Andel
St Andries
Lith
Maas
Grave
Well
Bergsche Maas
's-Hertogenbosch
Overflakkee
Schouwen
Hollandsch Diep
Mark
Zuid Willems Vaart
Dommel
Oester Schelde
Breda
Tilburg
Roosendaal
Zuid Beveland
Bergen op Zoom
Wilhelmina Kanaal
Helmond
Eindhoven
Venlo
Honte or Wester Schelde
Krefeld
Rhine
GERMANY
BELGIUM
Antwerp
Zuid Willems Vaart
Noorder Kanaal

the tidal range is greater than in the north, and the ebb occurs earlier. The greater range increases the tidal scour in the south-western estuaries. This lowers the base level of the branches discharging into them, so that an increasing proportion of the total volume of water flows in this direction, at the expense of the more northerly outlets. The effect of the earlier ebb is also to attract water in this direction. Small independent streams can also cut back their courses by headward erosion, eventually to capture the flow of an older branch. It is possible that the Lek was formed in this way: at least, this process increased its importance, so that it became the main outlet of the Neder Rijn in place of the Oude Rijn, which about 1250 was separated from the main river by a dam. Some Rhine water formerly found its way down the Hollandsch Ijssel, but this river is now separated from the Lek. The same increase in activity, but on a greater scale, occurred in the Waal. A stage in the process resulted in a well-known incident in Netherlands history. During storms and high river floods, in 1421, the sea broke through the dykes and flooded an extensive area around the mouths of the Waal and the Maas, forming the maze of channels and banks known as the Biesbosch, south of Dordrecht. Much water from the Waal was thus diverted south-westwards to the Hollandsch Diep. In the late nineteenth century the Nieuwe Merwede was constructed from the most important of these channels. The effect of the extension of the estuary upon the Waal became apparent at the point where it leaves the Rhine. In the Middle Ages this bifurcation was above Schenkenschanz, the Waal passing to the south. After the flooding of the Biesbosch, the volume of the Ijssel and Neder Rijn began seriously to dwindle, as an increasing amount was passing down the Waal. At the beginning of the eighteenth century a new channel, the Pannerdensch Kanaal, was cut from the Waal to the Neder Rijn, to increase the flow to the latter. The upper Rhine then became more active, while this portion of the Waal tended to silt up. Another channel, the Bijlandsche Kanaal, was cut in 1775 to stabilize the position. From this period dates the first convention regularizing the distribution of the Rhine water among the three distributaries, as detailed above.

The regulation of the Waal discharge has been further complicated by its relation to the Maas. In its course across the delta, the Maas in medieval times tended to draw closer to the Waal. Near Heerewaarden they are now only a few hundred yards apart, and they were formerly connected by three arms. As the level of the Maas is in general lower than that of the Waal, some flood water from the latter flowed into the Maas. If floods on the two rivers coincided, this water held up the flow of the Maas, causing further flooding in the upper valley. The position was further complicated, for the Maas, probably during the fourteenth century, had abandoned its lower course to the sea, and joined the Waal above Gorinchem. This junction added to the difficulties in disposing of the flood water rapidly, and a series of works have been carried out over a long period to separate the two rivers completely. Important stages in this have been the building of a great dyke between the rivers at Heerewaarden, where they are now connected only by the lock at St. Andries, and the provision of a new course for the lower Maas to the Hollandsch Diep. This, known as the Bergsche Maas, was a revival of the older course of the river below Well. It suppressed the portion of the river,

The lower Maas and Waal, from A. Arrowsmith's 'Holland fr
the map executed at the Dutch Military Dépôt,' London, 1

Giessen-Oudekerk
Giesendam
De Giesen
Sliedrecht
Hardinxveld
Schelluijnen
GORINGHEM
Dalem
Vuuren
Streefkerk
Werkendam
WOUDRICHEM
Brakel
Zuilichem
HET LAND
Rijswijk
Giessen
Uitwijk
Neer Andel
Poederooijen
Op Andel
Almkerk
Aalst
Veen
VAN ALTENA
DORDRECHT
Aalburg
Dussen
Hill
Babbenbroek
Genderen
Meeuwen
Eten
Heesbeen
Oud Heusden
Drongelen
HEUSDEN
Hedikhuijsen
Lage Zwaluwe
Hoge Zwaluwe
GEERTRUIDENBERG
LANGESTRAAT
Hasmedonk
Made
F. Steenhoven
Waspik
Besoijen
Zuide Wijn
Baardwijk
Washwijk
Drunen
Sprang
Oude Waert
Gravemoer
De Oude Maas
De Bakkers Kil
Hoog Kil
Mat Dorp
Alkenrade
Werken
Rijswijk
Neder Heusden

"afgedampte Maas," from Well to the junction with the Waal above Gorinchem, so that the only water from the lower Maas now reaching the Waal is the small amount which passes through the locks at Well and Andel. At the outbreak of war a further great control scheme for the Maas had practically been completed. Its bed has been dredged and widened, the level controlled by barrages at Lith and Grave, and its course straightened by cutting through the great meanders below Grave. Thus flood water can now be discharged directly and rapidly into the Hollandsch Diep.

Land reclamation

About two-fifths of the Netherlands lies below or close to sea-level, and is protected by dykes from the sea and the rivers. The area thus enclosed is of various types: the recent marine clays of the Zeeland islands and estuaries, and of northern Friesland and Groningen, generally a few metres above sea-level; the low peat districts mainly in North and South Holland, generally 1–2 metres below sea-level, but much lower where lakes have been reclaimed; and the districts adjacent to the great rivers practically throughout their courses in the Netherlands.

The methods employed to reclaim and drain these various types differ somewhat in each instance, and have left their mark upon the present topography. The task of maintaining them in a fit state for occupation, however, is much the same throughout, and a general system has been evolved as a result of centuries of accumulated experience. To understand the present conditions it is necessary to examine briefly the historical development.

At the beginning of the historical period, much of the area was a plain of low peat, resting on sands and old marine clays, probably mostly above sea-level but liable to flooding by high tides. Its outer edge was fringed by a belt of sand dunes, breached in the south-west by the great estuaries and in the north by the outlets of the Zuider Zee. In the south-west, where the tidal range was greatest, belts of recent marine clays were being built up by the tides upon the margins of the peat, and banks of sand and clay were constantly forming and re-forming in the estuaries. The tidal range is somewhat less in the north, but a similar process was also at work there. The conditions along the great rivers have already been described. By the thirteenth century dykes had been built along the sea coast and the rivers which gave general but not absolute protection to the interior. The problem of draining the enclosed areas adequately remained to be solved. In the case of the Zeeland islands, this was associated with their creation. As the banks were built up gradually, close to or above ordinary high water, they were enclosed by dykes to exclude exceptionally high tides, and the surface was then drained by natural flow through sluices in the dykes at low water. The building-up process then continued outside the dykes, so that successive strips could be similarly enclosed. Adjacent islands were also joined together by dams in the intervening channels. This is broadly the way in which the Zeeland islands were formed, *e.g.* Zuid Beveland: in the case of Walcheren, a portion of the coastal sand dunes existed to form a starting point. Similarly strips were reclaimed along the coasts of South Holland and Groningen. When land was thus enclosed, the surface tended to sink through consolidation and drainage, thus the

centres of the islands are lower than the newer, outer, land, and it ceases to be possible to drain the centre by natural flow; pumping is then necessary. At first it was customary to destroy the older dykes when more land was reclaimed, but this was given up owing to the risk of extensive flooding if the outer dyke should be breached. The typical Zeeland, or South Holland, island has a low central core unbroken by dykes, surrounded by successive dykes enclosing slightly higher land.

In the low peat districts the problem was rather different. On the margins the action of the sea has been destructive rather than constructive. During recent centuries the level of the land in relation to that of the sea has been falling, partly as a result of the shrinkage of the peat when drained. The action of the sea which enlarged a former freshwater lake into the Zuider Zee threatened also to erode and to submerge the peat. This danger was acute during the twelfth and thirteenth centuries. In addition to extending and strengthening the sea dykes, dams were built at the mouths of small rivers to exclude the sea water from the interior.

The effect of this was largely to deprive the land of its natural drainage, which in any case was not highly developed. Before it could be brought under cultivation some means of countering the high ground water-level, continually augmented by the rainfall, had to be devised. On the higher land it was possible to dry out the surface by enclosing small plots by banks, and leading off the water to the rivers, which could discharge it into the sea at low tide. But around the Zuider Zee the tidal range was less than elsewhere, and much of the surface was below or close to sea-level, so that other methods had to be found. Primitive ways of raising the water to the rivers by man or animal power were ineffective. In the sixteenth century windmills adapted to this purpose were introduced. These mills could raise water about 6 feet, and reclamation was then extended rapidly. Larger areas were enclosed by low banks, small ditches were cut to carry the water to a larger one, at the head of which stood the mill to raise it to the river. Since the water-level of the rivers was controlled by the dams and their banks were dyked, these had virtually been canalized and it was simple to extend the system by digging canals where required. Gradually it became possible to embark on larger undertakings. Over the interior of this low plain, especially north of the IJ, were scattered many lakes which had now been cut off from the sea. Since their beds were lower than the surfaces previously drained, the water had to be raised to a greater height. To achieve this, the device was used of arranging the mills in an ascending series (*molengang*) so that the water was raised in two or more stages. The lakes in the north were drained by this method early in the seventeenth century. Meanwhile south of the IJ, the condition of the surface, then largely bog, was becoming even worse through the activities of the peat cutters. Owing to the demand for peat as fuel, great areas of the bogs had been cut away, and abandoned as meres or swamps, leaving the villages and roads on isolated strips of the original surface, as is shown in the reproduction from Kruikius' atlas of Delflant. The improved methods allowed much of these areas to be reclaimed. The introduction of dredging for peat led to the extension of work to the shallow lakes, which were later drained. The old sea clay, exposed by the removal of the peat, proved very fertile. In some

instances peat was also dug away from the already reclaimed *veen* polders (peat polders). These clay areas form the chief arable districts of South Holland, the veen polders being mainly pasture.

When steam- or oil-driven pumps were introduced in the nineteenth century, it was possible to drain much deeper lakes: the reclamation of the great Haarlemmermeer was one of the outstanding achievements. In these drained lakes (*droogmakerij*) the present surface may be 4–6 metres below sea-level.

The term *droogmakerij* is also applied to the direct reclamation of land from the sea. In these instances, the enclosing dykes are built in the sea and the water then pumped out. The best known examples are the IJ polders reclaimed in connection with the building of the Noord Zee Kanaal in 1876, and the Wieringermeer, a portion of the Zuider Zee reclamation scheme. The surface of these are naturally several metres below sea-level.

Along the lower courses of the rivers, the adjoining land is below ordinary river level, and it is drained by the methods already described. Upstream the land is higher, and dykes are necessary for protection against the high winter levels of the rivers only, and drainage is generally by natural flow. The main problem is to control the flood water and dispose of it as rapidly as possible. The main dykes are usually at some distance from the summer bed of the river. The intervening stretches, known as *uiterwaarden*, are protected by banks against small rises of level, so that they can be used as summer pasture, or where they are high enough, as arable. During the winter the river, covering these *uiterwaarden*, extends from dyke to dyke, and may be as much as a kilometre wide. Even in these conditions the flood water might pile up and break through the dykes. To reduce the pressure on the dykes downstream and to limit the damage caused by a break, lower or weaker sections are left in the dykes (*overlaaten*) at points where flooding would be less disastrous. The flood water is eventually pumped back, or flows down to a point where it can be returned to the river. Large areas are thus inundated, villages isolated for long periods, and the land often rendered useless for agriculture. Progress in the improvement of the river courses however has largely removed the need for such measures. A district which suffered particularly before the improvements to the Maas extended along the south bank of the Maas from Grave to below 's-Hertogenbosch.

As a result of all this activity much of the Netherlands has been divided up into a series of independent units, many of which are below sea-level, and each with their own artificial systems of drainage. The control of the water levels at each stage and the disposal of exceptional quantities of water require an expert and vigilant administration.

The basic unit in the system is the polder. This is an area within which the subsurface water is isolated from the exterior circulation, generally by low dykes, and its level maintained, usually by pumping, at a predetermined level. A polder does not necessarily lie below sea-level, *e.g.* the Zeeland polders already mentioned, nor, as will be explained later, is it necessarily enclosed by dykes, though these two characteristics hold true throughout North and South Holland. The polder dykes are generally quite low banks, except those of the droogmakerien: in these cases they are massive constructions, owing

A veen polder from ''t Hooge Heemraedt van Delflant,' by N. and J. Kruikius,

E K POLDER
Bos Cat
Pynacker
Hoeven Zyt Windt
Lantscheyd
Berckel
Wateringe
Scheyt
Driemans

to the great damage a break would inflict. Polders are not generally further subdivided by dykes, but again the droogmakerien are exceptional: being reclaimed lakes, their borders are at a higher level than the centre, so that banks are necessary to prevent water flowing to the middle.

If the polder lies by the sea or a great river, the water can be evacuated by sluices or pumped out directly: otherwise it must first pass into an intermediary channel or storage basin. These are known as *boezems*, and may be formed by canalized rivers, such as the Oude Rijn, drainage canals, such as the Haarlemmermeer Ringvaart, or by the remaining lakes. In accordance with the hydrographical conditions, these are organized in groups, also known as boezems, or less confusingly as *boezemgebieden*. One of the best known of these is the Rijnlandsboezem. In each of these boezemgebieden a common water-level is maintained. The subsoil water-level in the polder is known as the *zomerpeil* (summer level), and is shown on topographical maps in metres above or below the Amsterdam datum level (Z.p. $\pm$ N.A.P.). It is determined according to the use to which the polder is put: in the veen polders, which are generally pasture, it is relatively high; in the arable polders it must be kept lower, and the general aim is to keep it about 1·5 m. below the surface. The actual level at a particular time will be shown approximately by the level in the ditches. The amount of pumping required to control it will vary with the local structure and the rainfall. Water may for example seep through from adjoining polders, and in some cases constant pumping may be necessary. The first stage therefore is the pumping of sufficient water from the polder to the boezem to maintain the required zomerpeil.

The level in the boezems also requires constant control. The *boezempeil* is fixed at a level which can be maintained with as little fluctuation as possible. Account must be taken of surrounding levels, and if the boezem is used for navigation a sufficient draught must be preserved. In some districts there are areas which drain naturally into the boezems, and their requirements must also be taken into consideration. If the boezem cannot deal with unlimited quantities of water, a danger level is fixed: when this is reached, pumping from the polders is temporarily suspended. In some polders a section is dyked off to hold the surplus water until discharge into the boezem can be resumed. The rapidity and efficiency with which the surplus water can be dealt with in an emergency is determined by the relation between the area of the boezem and the total area drained. In Rijnlandsboezem the proportion is about 1 : 33, so that the handling of exceptional quantities is difficult: in Frieslandsboezem, it is 1 : 12, so that floods can be more rapidly dispersed. The water in a boezem may be pumped directly into the sea, or may have to pass through another boezem, part of the water of Rijnlandsboezem, for example, is discharged into that of the IJ polders.

Frieslandsboezem differs rather markedly from those to the west. The general level is above that of the rivers: the polders are not enclosed by dykes, their subsurface water-level being controlled and their circulation isolated by sluices in the ditches. The system is designed principally to dispose rapidly of the winter floods, and this is assisted by the numerous lakes, which serve as temporary storage. Owing to the sandy nature of their beds, it would not prove profitable to reclaim them.

It is estimated that there are about 2,500 polders, and that the area drained by pumping is 2·34 million acres, and by gravity flow 0·98 million acres.

The area thus protected and drained is of vital importance in the economy of the Netherlands. It includes much of the best arable land in the country and valuable pasture: the capital, the principal port, and many important industrial areas are also situated there. It is only in the last half-century that most of the higher sandy districts of the east and south-east have been brought under cultivation, and more recently still that industry, attracted by cheap land and a good labour supply, has tended to move in the same direction. The light industries around Eindhoven are an example of this. Any extensive inundation in the west, even where the damage could be made good, would therefore have serious and prolonged consequences. Apart from the immediate loss of life and property, and the outlay of labour and finance required to restore the system, it would require probably three years at least to remove the effects of inundation by sea water and to bring the land under cultivation again. It is estimated by Dr. E. N. van Kleffens that if all the protected areas were inundated, 60 per cent. of the total agricultural, and 70 per cent. of the industrial production would be lost (*Foreign Affairs*, July 1944, pp. 546–7). The loss to agriculture would include 81 per cent. of the wheat, 89 per cent. of the sugar beet, and 63 per cent. of the milk.

Just as the course of reclamation has left its mark on the present topography, so it has affected the social and administrative life of the country. From an early date one or more polders have been grouped to form an administrative unit known as a *waterschap*. Throughout their history these had representatives of local interests working with an official of the central authority, and they are still to a certain extent autonomous. As the work of reclamation proceeded, larger bodies representing areas with a common interest came into existence. As they dealt with matters of vital interest, these *Hoogheemraadschappen* came to be powerful bodies which fought hard to maintain their authority against the cities and the government. However with the evolution of a more powerful central authority in the nineteenth century, their influence diminished. Nevertheless these bodies have defended the principle of election and the representation of local interests. The supervision of the work is now entrusted to departments of the provincial and national governments, known as *Provinciale Waterstaat* and *Rijkswaterstaat*.

THE OPENCAST MINING OF IRONSTONE AND COAL

W. DAVID EVANS

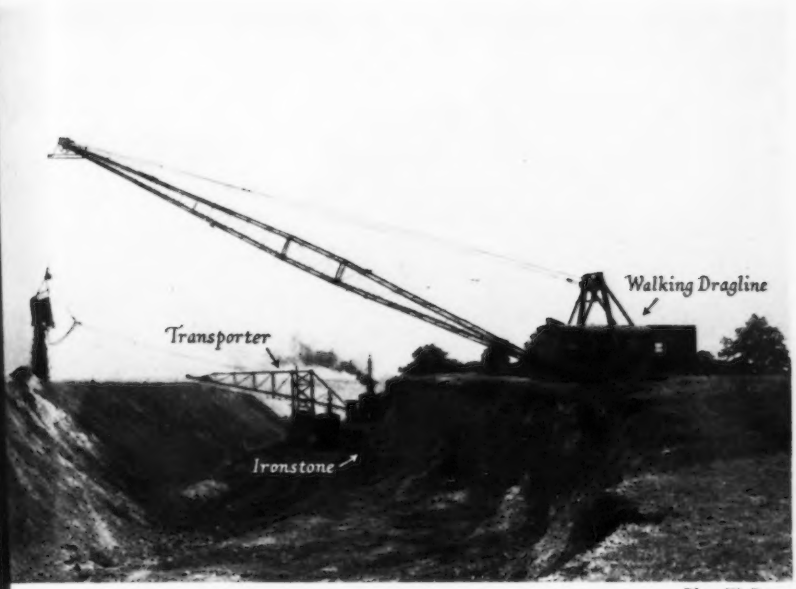
OPENCAST mining, or large-scale quarrying, of bedded minerals has been carried out in this country for over one hundred years. As distinct from underground mining it involves the removal of superincumbent strata, or overburden, which are discharged, or dumped, clear of the mineral exposed. Originally the overburden was removed by workmen who barrowed the material across the excavation along planks supported by high trestles; but since 1895 this has been superseded by mechanical excavators throughout the Jurassic Ironstone Field. This led to the development of a highly efficient system of mechanized opencast mining of ironstone, which has proved fortunate for the country during this war. As a result of past experience the ironstone companies have been able to step-up the output of home-produced iron ore to meet the ever-growing demand caused by enemy control of foreign sources.

The sudden demand in 1941 for an increase in the home output of coal coincided with a shortage of skilled miners to man the existing collieries, and led to the development of near-surface coal seams by opencast methods. This great war-time project was handicapped at the outset by a shortage of suitable mechanical excavators; but by the end of April 1944 over 7,552,000 tons of coal had been obtained in this way.

In general no appreciable decrease in the agricultural value of the land should occur if the soil is properly restored after the mineral has been extracted. The quality of the land is sometimes improved by the inversion of the original succession of strata in an area as the result of opencast mining. Where, for example, the beds consisted of sands overlain by clays a mixture of the two would result in an increase in the permeability of the ground. This all depends however on the completeness of the restoration, for by it is meant, not just levelling the land, but the replacement of the soil as well. In order to achieve this with the minimum expenditure of time and money the process of restoration must form part of the opencast operation, and should be an essential part of the lay-out of the mine.

When the opencast mine is planned carefully beforehand the mechanical excavators employed work to full advantage. Much of their mechanical efficiency is lost if they are moved about from place to place unnecessarily. Normally, when guided by an alert and dexterous operator, these machines are capable of performing the work of fifty or one hundred skilled miners; and they have done much to solve some of our labour problems in many spheres of war-time activities. Mechanical excavators have been used to level land for aerodromes, they have improved our drainage schemes, and they have often cleared debris to make way for our troops.

From experience it has been found that the following systematized approach to the planning and working of opencast sites results in a minimum expenditure of effort, and provides the solution to most of the problems encountered in opencast mining of all kinds.



Phot. W. Barnes

1. Walking dragline and power shovels with transporter in an ironstone pit

Phot. W. Barnes

2. Electrically-driven power shovels excavating ironstone and overburden

Phot. W. I

3. Caterpillar-mounted dragline excavating ironstone, and stripping and level overburden

Phot. G. H. W

4. Power shovel excavating coal, and draglines stripping overburden

1. Suitable sites are selected from the 6-inch geological maps of H.M. Geological Survey. These maps are available for the main part of the Jurassic Ironstone Field, and for all the coalfields in the country, with the exception of Somerset, which is now being surveyed.

2. The selected site is investigated by the examination of existing outcrops followed by the digging of trial holes or trenches. If the mineral is not of a workable quality then the land is returned to the farmer.

3. If the mineral is workable then the site is further prospected by a series of boreholes put down at points selected by the geologist to provide the maximum amount of information. The level of the top of each borehole above O.D. is calculated, and the strata proved carefully recorded. Borehole samples of the mineral are also collected and analysed.

4. Isopachyte Plans of the site are then constructed to show the variation in thickness of the beds above the mineral, and of the mineral itself. These plans should be drawn to the same scale as that used by the engineer for his final lay-out of the mine.

5. Contour Plans of the top, or of the base, of the mineral should then be drawn on the same scale. These will show the disposition of the mineral at depth. This is necessary as frequently the variations in gradient of the deposit bear no resemblance to the topography of the site, and by means of these plans the engineer will be able to devise a drainage system for the pit before operations begin.

6. Where the mineral shows great variation in composition, as in the case of ironstone, a plan showing the distribution of the main chemical constituents of the deposit can be constructed. This will assist in delineating the workable area.

When the preliminary surveys have been completed and the geological plans drawn up, the engineer, in consultation with the geologist, is then in a position to formulate the lay-out of the opencast operation. From these plans it will be possible for him to determine the most advantageous position for the initial excavation, the type of machinery necessary to excavate the amount and type of overburden shown by the isopachyte plans, as well as how to negotiate successfully any discontinuities that may occur in the deposit. Further, plans can be drawn out at this stage to incorporate the restoration of the land, so that it can be effected with the minimum expenditure of time and money. In the succeeding description of the opencast mining of ironstone and coal these points will be referred to, together with the control which the nature of the overburden, the chemical composition of the mineral, and the geological structure of the ground impose upon this method of working these deposits.

Opencast Mining in the Jurassic Ironstone Field

Beds of ironstone occur on several horizons in the Jurassic rocks throughout eastern England. Of these only the Frodingham Ironstone (Lower Lias), the Marlstone Ironstone (Middle Lias), and the Northampton Sand Ironstone (Inferior Oolite) have proved to be workable over large areas. The distribution of these three ore-beds throughout the main part of the Ironstone Field are shown in Fig. 1.

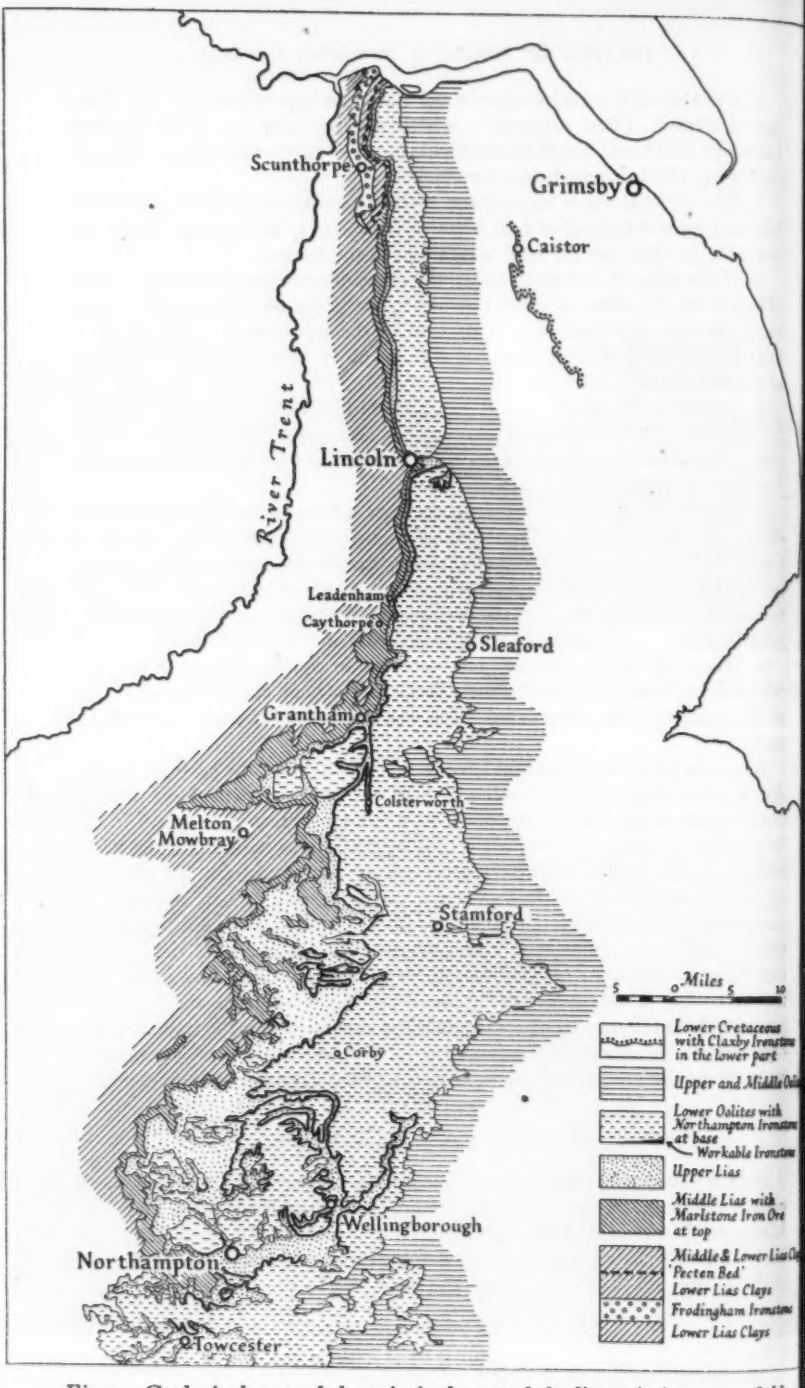


Fig. 1. Geological map of the principal part of the Jurassic ironstone field

The *Frodingham Ironstone* is restricted to the neighbourhood of Scunthorpe, north Lincolnshire, where it occurs in the shales and clays of the Lower Lias formation. It extends for over 7 miles southwards from near the Humber, and forms a broad outcrop up to 2 miles wide. The unweathered ore is a dark-green lime-rich ironstone, but over large areas, particularly at outcrop, it is almost completely oxidized to a soft brown limonitic ironstone with a much reduced lime content. Glacial gravels and blown sand conceal large parts of the outcropping ironstone, and to the east the overlying shales and clays of the Lower Lias limit the extent to which the ore can be worked by opencast methods.

The *Marlstone Ironstone*, as such, occupies a well-defined horizon at the top of the Middle Lias formation. In Lincolnshire it is about 7–12 feet thick where workable, and averages about 12 feet in Leicestershire. Through Northamptonshire the ironstone is about 6 feet thick, but increases to as much as 30 feet in parts of Oxfordshire. The unweathered ironstone is usually a greenish-grey lime-rich ironstone which at outcrop, and for a limited distance beneath the succeeding Upper Lias shales, is oxidized to a brown limonitic ironstone. Broad outcrops of the Marlstone Ironstone are concealed in many places by glacial gravels and boulder clay, and in places these deposits fill channels excavated right through the ore-bed in pre-glacial times.

The *Northampton Sand Ironstone* lies above the Upper Lias shales. In north Lincolnshire the deposit is unworkable, but between Lincoln and Grantham 9 feet of ironstone has been worked at several places. In south Lincolnshire the ironstone is often as much as 26 feet thick, but it thins to 10 feet in places in Rutland. In Northamptonshire the ore is generally about 12 feet thick, but in places there is as much as 20 feet. In the western and southern parts of this county the ironstone is represented by sands or by sandy ferruginous limestones. When unaltered the ore consists of a greenish-grey carbonate ironstone containing a relatively high percentage of silica, but over large areas it has been oxidized to a brown limonitic ironstone.

Chemical composition.—In the early days of working in the Frodingham Ironstone only the more completely oxidized parts of the ore-bed were extracted from the pits for smelting. This necessitated selective hand-digging, and prevented complete mechanization of the opencast workings. When it was discovered that the Frodingham Ironstone could be profitably used as a ferruginous-calcareous flux in the smelting of the more siliceous Northampton Sand Ironstone, selective hand-digging was replaced by a fully mechanized excavation of nearly the whole of the ore-bed. The Marlstone Ironstone is now largely used in the same way. In parts of Leicestershire however, particularly in the Melton Mowbray district, the Marlstone Ironstone contains iron, silica, and lime in such proportions that it is almost self-fluxing and is smelted as an independent source of iron.

The chemical composition of the ore is often related to the nature of the overburden. Most calcareous ironstones are not worth working unless they are oxidized. The Frodingham Ironstone is often largely unoxidized under relatively small thicknesses of Lower Lias shales, but it has been found workable even in this condition. The Marlstone Ironstone is usually unoxidized when

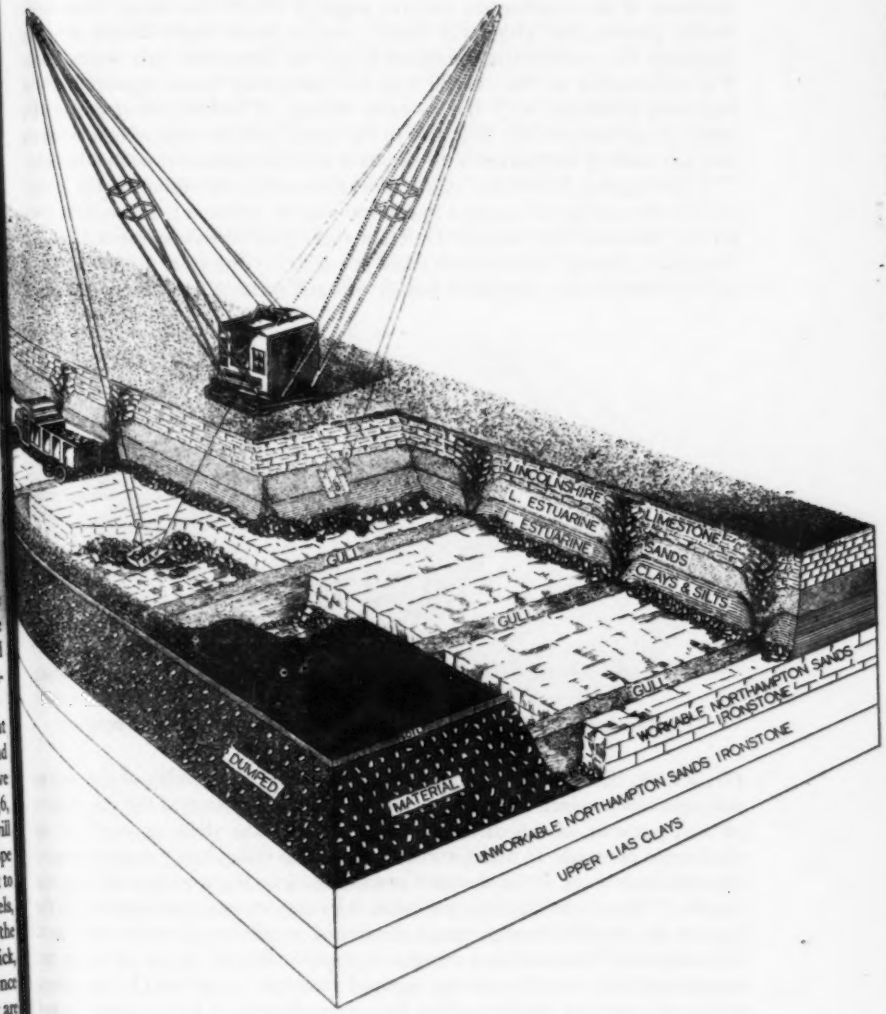
the cover of Upper Lias Shales reaches 30–40 feet. This is no doubt due to their impervious nature. The ironstone has been worked under greater thicknesses of cover where the overburden consists of glacial gravels and boulder clay, the ore having been largely oxidized prior to their deposition. The oxidation of the Northampton Sand Ironstone has been to some extent caused by percolating waters, whose entry into the ore-bed is controlled very largely by the permeability of the overlying strata. Naturally this is also complicated by the circulation of underground waters in the ironstone, but in all cases attention is paid to hydrogeological factors when a site is being selected for opencast mining.

The chemical composition of the ore plays its part in the planning of the opencast mine, as the quality of the stone will determine the amount of overburden which can economically be removed. If the composition of the ore is such that it needs calcining before putting it on rail to the furnaces provision has to be made, either within or outside the opencast mine, for space in which to form the calcining heaps.

Overburden.—In areas selected for opencast mining not only the thickness of the overburden, but also the beds comprising it must be considered, as upon these will depend the choice of machines to be used for the operation. Power Shovels (see p. 118, and Plate 2) or Rock Navvies are generally used to remove thick beds of limestone and to excavate the ironstone. These machines always excavate above the level at which they stand. Sands, gravels, and clays can be removed by a Dragline Excavator (see p. 118, and Plate 1), which is also capable of digging loose beds of limestone which have been shattered by blasting beforehand. This machine normally stands on the surface of the unworked ground and digs below this level. Tractor-drawn Scrapers (see p. 118, and Plate 3) are capable of removing soft beds of sand, shales, and clays, but limestone or sandstone in the overburden prevents them from completing the stripping operation.

The gradient at which the face of the overburden will stand without collapsing during the working of the site will depend upon the nature and thickness of the overburden, and the period of time between each successive traverse of the excavator. Ries and Watson ('Engineering geology,' 1936, p. 381) suggest that solid beds of sandstone, limestone, and hard shales will stand at a gradient of 10 in 1, but if these beds are jointed or fissured the slope is reduced to 7 in 1. When these beds are saturated with water, and subject to frost action, these gradients are greatly reduced. Soft beds like sands, gravels, and clays will stand at a gradient of 1 in 2. In large opencast pits where the working face is up to half a mile long, and the overburden over 40 feet thick, the stripping machine rarely traverses the length of the pit more than once every four weeks. Under these conditions the above estimates of gradient are reasonably accurate. Where the pit is smaller and the machine travels along the face of overburden more than once every three weeks, steep gradients are often maintained even in soft beds of clay, particularly during dry weather.

A bench of ore should be left free of the overburden to prevent the exposed ironstone being contaminated, and concealed by debris slipping from



Dragline excavating ironstone and restoring worked out area. A. bucket digging ore; B. bucket digging overburden

this face (see Fig. 3). This retention bench is maintained by excavating only a part of the exposed ore-bed, and its width must depend on the nature and thickness of the overburden, and the angle at which it is being excavated. Sands, gravels, and clays will clearly need a much wider bench than is necessary for overburden composed largely of limestones and sandstones. The importance of this bench has not altogether been appreciated by engineers concerned with the opencast mining of bedded ore-deposits. In many places however the thickness of the cover, and the type of machines in use, has made it impracticable to maintain adequate space for such a bench.

A pre-existing knowledge of the thickness and composition of the overburden also assists the engineer in determining the width of the reception area for the excavated overburden. Different rock-types when excavated and discharged in a loose condition will stand at angles varying from 30° for clays to 40° for overburden composed mainly of hard rock. A convenient estimate

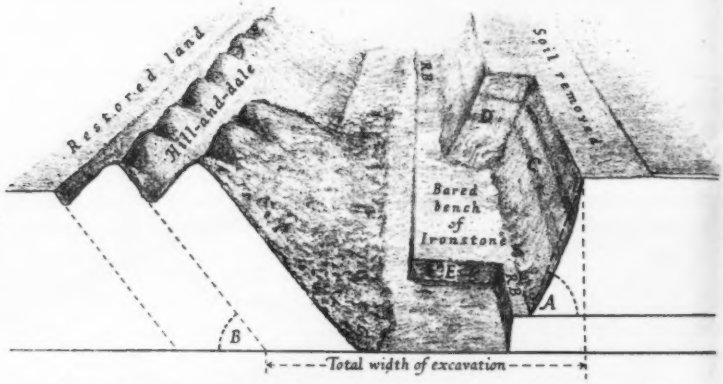


Fig. 3. Diagram illustrating the terminology used in opencast mining

(W. Barnes, 'Excavating machinery,' 1928, p. 148) of the width of the reception area is one which is equal in width to the cross-section of the excavation plus 25 per cent. of this distance to accommodate the yield, or swell, of the discharged material. In many ironstone pits great difficulties are encountered through landsliding of the dumped overburden into the workings during wet weather. These landslippings are induced by surface water percolating to the base of the deposit through cracks developed parallel to the excavated face. To counteract this as wide a margin as possible should be left between the bared bench of ironstone and the dumped material. It will also be necessary to keep the gradient of the working face of overburden as low as possible and to construct drainage benches ahead of the workings to lead off surface water.

Geological structure.—The dip of the strata and the topography of the land largely determine the thickness of cover over the ironstone within an area, so that the ideal is reached when the slope of the land approximates in direction and degree to the dip of the ore-bed. The presence of faults and folds in the

ironstone will also affect the amount of overburden present, and they seriously hinder the smooth working of an opencast pit, as excavators work best on level or steadily inclined surfaces.

The geological structure of the Frodingham Ironstone is remarkably simple. The bed dips gently eastwards at rarely more than 3°, and apart from small folds, which usually extend from north to south, and faults rarely throwing down the beds more than 10 feet, the ironstone preserves a very even surface. Similarly the geological structure of the Marlstone Ironstone is very simple, as in only a few places is it affected by small faults and folds. Thus in both these ore-beds large pits have been excavated by mechanized methods.

The geological structure of most of the Northampton Sand Ironstone has been complicated by the effects of relatively recent large-scale superficial movements. As a result of these the beds of ironstone have frequently been

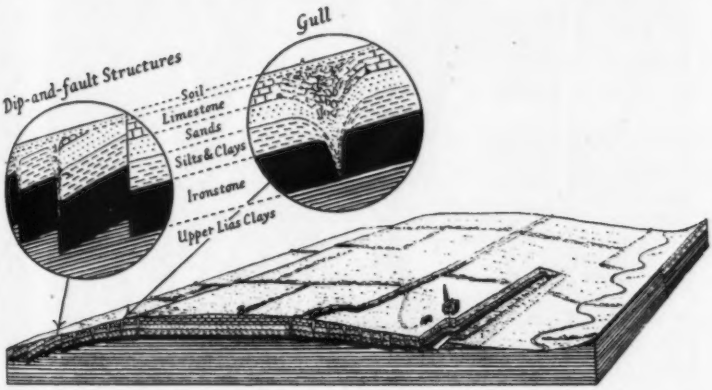


Fig. 4. The relation of superficial disturbances to topography

lowered downhill mainly by movements induced within the clays of the Upper Lias during valley formation. This phenomenon is known as *Cambering* (S. E. Hollingworth and Others, "Large-scale superficial structures in the Northampton Ironstone Field," *Quart. J. Geol. Soc.*, 100 (1944) 3), and has given rise to the formation of fissures, or *Gulls* (see Fig. 4), in the ironstone, usually filled with sands, silts, and clays derived from the Lower Estuarine beds above. In general these gulls extend roughly parallel to the contour of the land. In areas, such as on the flat crest of a spur, or on well-graded valley-sides, the cambering of the strata has developed an appreciable dip, and the beds are often dislocated by *Dip-and-fault* structures (see Fig. 4). These consist of a series of parallel, steeply inclined, fractures between which the beds are tilted sharply downhill causing an appreciable downthrow on the uphill side of the dislocations. A step-faulted arrangement of the beds is thus formed in which the downhill dip of the strata largely compensates the throw of the faults. Gulls are almost invariably developed along these lines of dislocation.

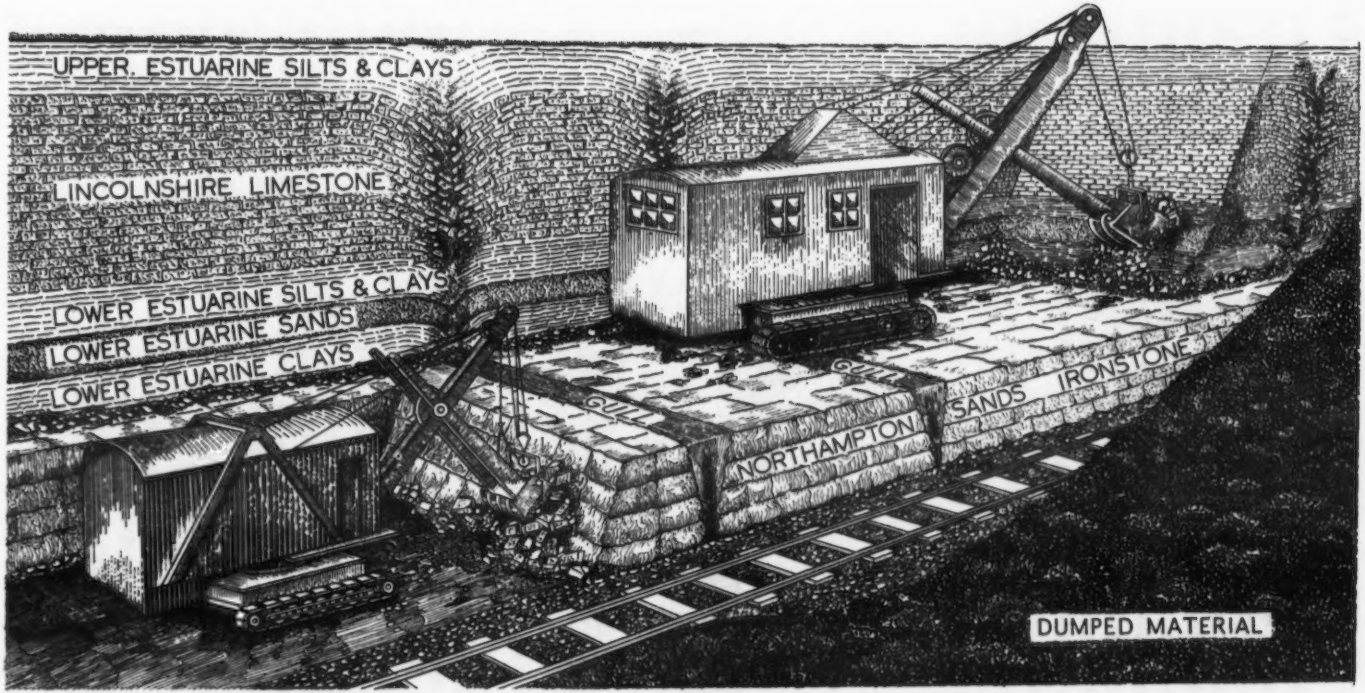


Fig. 5. Power shovels excavating ironstone and overburden at right angles to the gulls

Valley bulges are also the result of superficial movements consequent upon valley-formation. In their simplest form they consist of "anticlinal uprises of the material composing the valley floor . . . as a simple or compound fold, or a series of discontinuous elongated domes" (S. E. Hollingworth, 1944). Valley bulges are responsible for areas of outcrop stone that have led mining engineers to undertake much fruitless exploration, as such outcrops are always severely disturbed and of limited extent. Most of these occurrences have now been mapped by H.M. Geological Survey so that much time and money can be saved in exploring the possibilities of such outcrops of ironstone.

As a consequence of the realization that gulls filled with sands and clays in the ironstone usually run parallel to the contour of the land-surface, methods can be devised for working such hitherto neglected areas. In general it may be found advisable to excavate the ironstone as nearly at right angles as possible to the alignment of the gulls. In this way the ore can either be removed from between each pair of gulls by a dragline excavator (see Fig. 2), or that part of the gull which is exposed can be quickly dug out and dumped on one side by a power shovel (see Fig. 5). Further, if considerable thicknesses of limestone occur in the overburden it can be more easily excavated in this direction by a power shovel, as these beds have been loosened by the downhill cambering of the strata.

Where dip-and-fault structures are present the alignment of the working face parallel to the direction of the lines of dislocation takes full advantage of the loosening effects caused by the downhill tilting of the beds. It must be noted however that this practice has the serious disadvantage of working a face parallel to the gulls which will occur in the ironstone farther uphill (see Fig. 4).

Restoration.—In the past, large areas of the Ironstone Field have been devastated by opencast mining since, in a number of places, no attempt has been made to restore the land. Apart from the obvious wastage in valuable agricultural land, when the overburden is left in rough hill-and-dale formation it forms a breeding ground for rabbits and other vermin and becomes a centre for the dissemination of weeds. While condemning this practice it should be borne in mind that in the days when this ground was being worked the power shovel was the only type of excavator available. The employment of hand-labour for this task would have been too heavy a charge to put on ironstone, the market value of which, even at the present time, is rarely more than five shillings per ton on rail. It is therefore necessary to incorporate the process of restoration into the mining operation as a whole, so that it can be discharged with the minimum expenditure of money and time. It has been estimated that up to the end of 1939 about 3,000 acres had not been restored to agriculture. This in no way compares with the amount of land allowed to remain unproductive before the war, but its occurrence in a dominantly agricultural area is serious.

Where power shovels are employed for excavating the overburden they discharge it in a "hill-and-dale" fashion (see Fig. 3). The height of the "hills" is dependent upon the type of excavator and the thickness and nature of the overburden. The more pronounced the hill-and-dale character becomes, the

more expensive it is to level; therefore attempts should be made to vary the dumping points as frequently as possible so that material is continually being discharged into the "dales." Power shovels are incapable of taking part in the levelling of the discharged overburden, and they are also unable to strip off the soil prior to the excavation of the cover. Therefore in all areas where they are employed care must be taken to remove, and store, the soil in a suitable place clear of the ground to be worked over. Where power shovels are indispensable it should not prove difficult to arrange for tractor-drawn scrapers to remove the soil strip by strip as the pit develops, and then relay it over those parts of the worked-out areas which have been levelled by a bulldozer.

Where dragline excavators can be employed, hill-and-dale formation can be avoided or reduced to a minimum. A dexterous operator is able to fling the

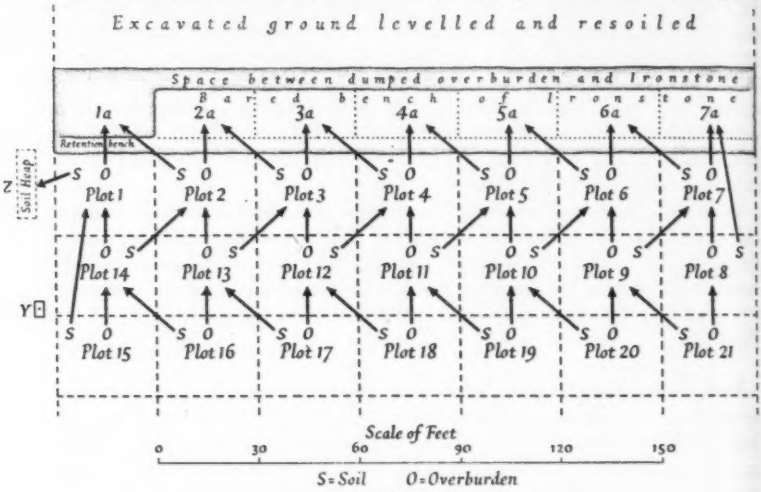


Fig. 6

bucket at the point of discharge in such a way that the material is spread over the previously excavated area (see Plate 3). These machines are also capable of levelling each panel of discharged overburden and resoiling it with soil obtained from the next piece of ground to be removed. In this way the final restoration of the land becomes an essential part of the mining operation and proceeds with the development of the pit. Fig. 6 shows a working face which has been developed in conjunction with the restoration of the land. The soil from Plot 1 was stripped and discharged into a heap located at Z. The overburden from Plot 1 was afterwards removed and dumped and levelled on the area 1a; but at the same time the excavator was removing the ironstone a little ahead of the discharged material (see Fig. 2). The soil from Plot 2 was used to resoil the levelled overburden excavated from Plot 1, and the overburden in Plot 2 discharged into area 2a, which had by now been cleared of ironstone. In this way the dragline traversed the first strip to Plot 7, when it was placed at point X to resoil the overburden of Plot 7a with soil taken from Plot 8.

The excavator then proceeded to retraverse the pit in the opposite direction digging ironstone, excavating, levelling, and resoiling the overburden in the same way as before. The discharged overburden from the last plot of this strip was resoiled by placing the excavator at point Y to strip the soil from Plot 15. In this way the site was systematically exploited and at the end of the operation the land was in a fit state to be returned to agriculture. Actually, during the working of the site the restored ground at the western end of the site was cropped with potatoes, and the land to the east of the pit was farmed continuously.

When the land has been finally restored it will naturally be subject to varying degrees of subsidence due to the compacting or settling of the loose material. The degree of settlement will to some extent depend on the original composition of the overburden, and also upon the way in which it has been discharged and levelled. Power shovels invariably deposit the material in a relatively uncompacted state. When this is levelled by bulldozers it is to some extent compacted, but settlement will usually proceed for periods varying from six to eighteen months. When the ground has been restored by the dragline method it is quite uncompacted, and a much longer period will elapse before settlement of the land is reasonably complete. If the overburden is excavated and discharged evenly by tractor-drawn scrapers each layer will be well compacted by the passage of each succeeding machine over it. Since each layer deposited is usually about 6 inches thick the compacting effects are considerable, particularly as scrapers are in general use for removing clays, silts, and shales. Ground restored in this way is often less pervious than it was originally, but it is not affected generally by subsidence.

Much has been written about the methods for restoring the productivity of this devastated land, but most of it has been summarized in the Kennet Committee report on the 'Restoration of Land Affected by Iron Ore Working' (1939, Min. of Health, H.M.S.O.). It remains to be seen whether their recommendations will be adopted, but for the future there are no insuperable mechanical difficulties to prevent ironstone companies from restoring the land as part of the opencast operation.

The Opencast Mining of Coal

In the early days of coal-mining in this country the near-surface seams were worked from adits driven into them from, or near, their outcrops, or from a system of closely-spaced shallow pits. At the present time the collieries are situated well down-dip from the outcrop of the coal seams so as to avoid the many problems of near-surface mining, and to obtain the higher grade coals. When the opencast mining of near-surface seams was first suggested during this war it seemed as though the Coal Industry had wisely considered outcrop coal to be a vanished asset. "Fortunately, however, a thorough investigation was made, and some districts have proved amazingly fruitful, especially in the Notts.–Derby and Yorkshire fields, where the 'old men' had spared an unexpected proportion of near surface coal" (E. B. Bailey, "The natural resources of Great Britain," 1944, Cantor Lecture, *J. Roy. Soc. Arts*, 92 (1944) 538–45). Major-General K. C. Appleyard, the Director of Opencast

Coal Production, has described how this enormous task was organized in the latter part of 1941, and gives figures to show how the production of coal in this country was greatly assisted in this way, despite many difficulties (*J. Inst. Fuel*, 17 (1944) 78–9).

The geology of the British Coalfields is far more complex than that of the Jurassic Ironstone Field. Precisely the same geological considerations, and methods of approach however, are applicable to the opencast mining of near-surface seams of coal. Generally speaking seams of coal less than 3 feet thick are not excavated, unless they occur above a thicker seam. Sites are only worked where "the ratio of overburden to coal does not greatly exceed 5 to 1" (K. C. Appleyard, 1944, p. 78).

In the South Wales Coalfield the possibilities of working coal in opencast pits is seriously limited by the Pennant Sandstone, which overlies the main productive part of the Coal Measures. There are however a few places where the slope of the land and the dip of the seam lend themselves to this type of working, and coal has been excavated at these sites even from beneath considerable thicknesses of the sandstone. In the Forest of Dean Coalfield there are no sites where coal can be excavated in this way, owing to adverse geological conditions and old workings.

In the Midland Coalfields the principal, and most hopeful, areas are already being worked opencast, and others are still being prospected. Here the workings are complicated by the rapid variation in the thickness of the seams, steep dips at outcrop, and by the presence of small faults dislocating the seams.

In the Notts.–Derby and Yorkshire fields the seams frequently dip at low angles, and they are not seriously affected by faults. Many successful sites have been developed, and the bulk of the output of opencast coal has been obtained from these areas. Opencast coal has also been obtained from Scotland at sites selected by the Geological Survey, but in general the structure of the coalfields here is too complicated for the development of large opencast sites.

In all the coalfields the working of large opencast sites is restricted by the presence of old near-surface workings. They are not always easy to detect, and frequently there are no mine plans to show their existence and extent. It has therefore been the sad experience of most opencast engineers in charge of sites to find old workings suddenly appearing in the working face of the pit. In some cases it has been found possible to extract the pillars of coal left in the old mine, but as a rule their presence leads to the abandonment of the site.

Quality of outcrop coal.—The quality of coal obtained from opencast pits is usually determined by the absence or presence of "dirt-bands" in the seam, and the prevention of material from the overburden contaminating the coal as it is being excavated. In the early days the quality of the coal was discredited, in some cases justifiably, but with improved mining methods, and the installation of screening plant and washeries, a reasonably high-grade fuel is now being produced.

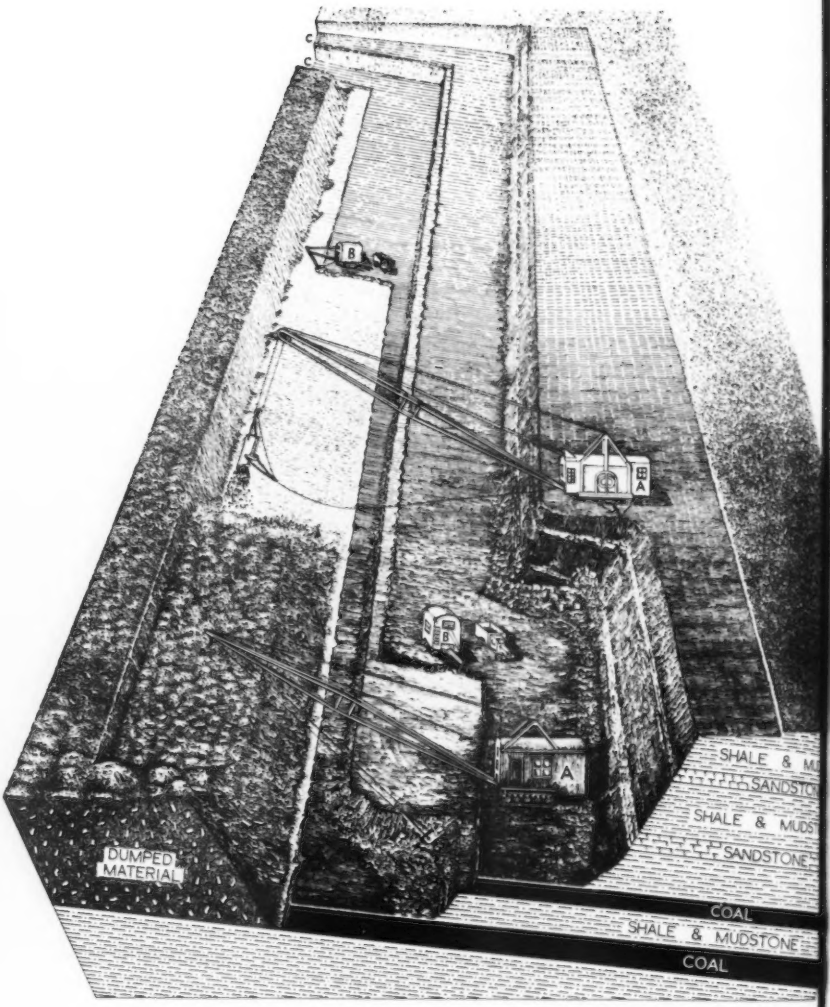
Overburden.—In general the same remarks apply to the stripping of the mudstones, shales, and sandstones which usually overlie the seams, as were

Phot. G. H. Mitchell

Scraper discharging overburden during restoration of a worked-out area of coal

Phot. W. Barnes

Bulldozer levelling dumped overburden. Hill of discharged overburden in the ground



7. Opencast mining of two seams of coal. A. Dragline excavator; B. Back-acting power shovel; C. Exit roadway on bared surface of coal

made earlier with regard to ironstone. It has however not been appreciated that to keep the coal clean as wide a bench as possible should be maintained below the face of overburden. It has not always been possible to do this, owing to the lack of dragline excavators possessing a dumping radius great enough to leave room for the bench of coal.

Owing to the discharge of the excavated overburden on to relatively steeply inclined areas of worked-out ground, great difficulty has been experienced, particularly during winter months, in preventing it from subsiding into the workings. To overcome this a much lower angle of rest for the discharged material must be allowed, which calls for a much wider reception area than is the case in ironstone pits. Large excavators must therefore be employed, and care must be taken in the lay-out of the mine to provide the widest possible excavation at the outset.

Geological structure.—Before the ground is excavated its geological structure must be thoroughly investigated. The faults and folds which frequently occur in coal seams are often so severe that the site has to be abandoned. Underground water also presents many problems, but by using contour plans of the top of the seams, the engineer should be able to find a solution for them.

Restoration.—All sites excavated by the Directorate of Opencast Coal Production are fully restored to agriculture at the end of the mining operation. The sites so far exploited have been relatively small, and the amount of overburden removed has rarely been more than 60 feet thick, so that the land has been restored to the farmer after a period of from nine to eighteen months. The results of restoration have been extremely good as no expense has been spared to redeem the former quality of the land. In many cases the land has been improved as the result of excavation, and frequently variations in the former contour of the ground have been smoothed out.

Systematic planning and working of an opencast coal mine.—To illustrate this a site has been chosen where two seams of coal are worked simultaneously. Fig. 7a is the geological map of the ground where the seams dip to the south, and are dislocated by faults ranging in throw from 12 to 80 feet.

Trenches were dug at suitable points selected by the geologist, and samples taken from the seams were analysed in the Fuel Research Laboratories. The coal in both seams was found to be of workable quality. A series of boreholes was then put down to check and supplement the data given by the geological map of the site. The level of each borehole was taken, and the beds proved by them carefully recorded. From these data an isopachyte map (Fig. 7c), showing the distribution of equal thicknesses of cover, and a contour map of the top of the upper seam (Coal I in Fig. 7b) were drawn. The boreholes also showed that the beds were saturated with water so that allowances had to be made to deal with this in the plans of the mine. It was considered that the maximum thickness of overburden which could economically be removed was about 80 feet. The presence of two beds of sandstone in the overburden (see Fig. 7a) prevented the use of scrapers for removing the overburden. Further, the three faults downthrowing the beds 30, 60, and 80 feet on the west, south, and east sides of the ground delineated the workable area of coal. The small N.N.W.–S.S.E. fault downthrowing the seams 12 feet on the west was considered to divide the site into two parts for the opencast operation.

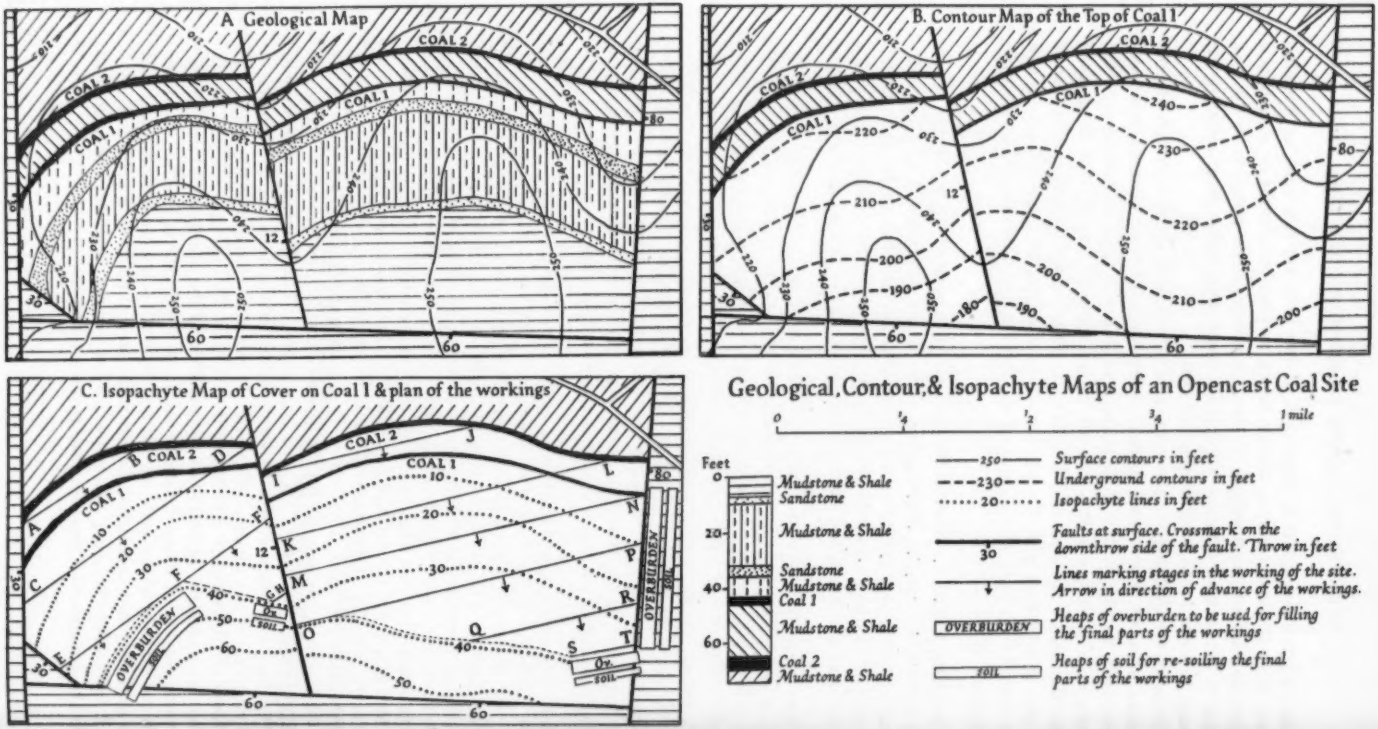

A Geological Map
B. Contour Map of the Top of Coal 1
C. Isopachyte Map of Cover on Coal 1 & plan of the workings
COAL 1
COAL 2
OVERBURDEN
SOIL
Geological, Contour, & Isopachyte Maps of an Opencast Coal Site
0
¼
½
¾
1 mile
Feet
Mudstone & Shale
Sandstone
Mudstone & Shale
Sandstone
Mudstone & Shale
Coal 1
Mudstone & Shale
Coal 2
Mudstone & Shale
Surface contours in feet
Underground contours in feet
Isopachyte lines in feet
Faults at surface. Crossmark on the downthrow side of the fault. Throw in feet
Lines marking stages in the working of the site. Arrow in direction of advance of the workings.
Heaps of overburden to be used for filling the final parts of the workings
Heaps of soil for re-soiling the final parts of the workings

Fig. 7

In order to provide a constant slope for drainage in one direction the initial excavation was made by a dragline in the lower seam between A and B (Fig. 7c). A dragline was employed for stripping the overburden. This material was transported to a reception area near the line EF until sufficient had been accumulated to fill the final workings at this part of the pit. The bared coal was excavated by a back-acting shovel which digs below the level of the top of the seam upon which it stands. In this way the workings were advanced until a workable amount of the upper seam was exposed in the face of overburden. At this stage a second set of similar excavators was installed to strip the overburden from the lower seam and dig out the coal. Both seams were now developed simultaneously, with each stripping machine dumping the overburden in the previously excavated ground. The relative capacity of each machine had been calculated to ensure that the removal of the bared coal kept pace with the stripping of the overburden. The relative positions of the machines, at one stage in the whole mining operation, is shown in Pl. 7. It was also arranged that each stripping machine discharged the overburden against the exposed fault face on the west side of the pit at the beginning of each cut. In this way room was left between D and H (Fig. 7c) for exit roadways formed of bared coal along which the coal could be hauled to ground level from the pit.

The pit was excavated in this way until the position EF (Fig. 7c), marked by the 40-foot isopachyte line, was reached. The workings between these two points were filled, levelled, and resoiled with the material previously deposited; but the part of the face beyond F to the north-east was advanced farther down dip to its final stage between G and H. The exit roadways formed of bare coal between D and H were then removed, but the gullet was allowed to remain open to act as a reservoir for the water which would drain out of the next series of excavations on the upthrow side of the fault.

The eastern half of the site was excavated in the same way as the western, starting with an initial gullet between I and J. The overburden was heaped in reception areas between ST and NT. Sufficient soil was also dumped behind these heaps to be used for resoiling the filled-in parts of the final workings. As the working face advanced from IJ through KL and MN to OP the open gullet left between D and H in the previous part of the operation, was steadily filled in. This enabled exit roadways on the bared surface of the coal seams to be maintained between N and T. When the position OP was reached the pit became progressively narrower as it was limited by the 40-foot isopachyte line between O and S. The overburden was consistently dumped against this line until the final position ST was reached. The coal still left in the roadways between N and T was then removed and the final gullets filled and resoiled by using the material previously deposited nearby for the purpose.

Throughout the whole of the opencast operation the dumped overburden was levelled and resoiled by tractor-drawn scrapers and bulldozers. These scrapers had been employed to strip off the soil ahead of the working face of the pit, to be used for resoiling the levelled overburden dumped in the worked-out area. In this way the land was restored within a few weeks after all the available coal had been removed. The land was then seeded with grass and returned to the farmer. When settlement was considered more or less complete new drains were made, and the ground fully restored to agriculture.

The author wishes to acknowledge the help given to him by Mr. W. Barnes and his colleagues of the Geological Survey. To Sir Edward Bailey, Director of the Geological Survey, the author wishes to express special thanks for his encouragement, and for permitting the publication of this paper.

Notes on Excavating Machinery, by W. Barnes

There are many types of mechanical excavators in existence, but of these the Power Shovel, Dragline, Scraper, and Bulldozer are the most widely used for opencast mining in the Ironstone Fields and Coalfields of Great Britain.

The Power Shovel, or Rock Navvy, consists of an elaborate shovel, or bucket, at the end of an arm suspended from a boom, which extends crane-like from that part of the machine which houses the power-plant (Plate 1). When digging the bucket moves forward and upward, so that the machine does not usually excavate beneath the level at which it stands. The original steam-driven power-shovels have now largely been replaced by diesel or electrically driven excavators. Caterpillar mountings, or self-laying tracks, have almost entirely replaced the rail-wheel mountings of the earlier machines. The power-shovels used for digging ironstone or coal are usually fitted with short booms, but the larger machines employed for stripping overburden are fitted with the longest boom possible (Plate 2). The largest power-shovel used for stripping overburden in this country weighs from 600 to 700 tons, and is fitted with a bucket of 9–11 cubic yards' capacity, which dumps the overburden at a distance of about 105 feet. Machines of similar design, but weighing up to 1200 tons and fitted with a bucket up to 33 cubic yards' capacity, are in use in the opencast coal workings in the U.S.A.

The dumping radius of an excavator is of the utmost importance since it must discharge the excavated material as far as possible into the worked-out areas of the mine. In order to increase the limited dumping range of most power-shovels, an additional machine, known as a Transporter (Plate 1), has been used in many of the ironstone workings.

The Dragline Excavator is a crane-like machine with a bucket suspended on a long light boom, which is dragged by a steel rope towards the power plant. In this way the excavator is capable of digging material well below the level at which it stands, and in most cases it is able to discharge the overburden in a levelled condition (Plate 3). In many places this machine also replaces the soil on the levelled worked-out areas. Unfortunately the digging power of the dragline is not as great as that of a power-shovel, and it has been found unsuitable for removing thick beds of hard rock unless they have been previously shattered by blasting.

Dragline excavators are usually mounted on caterpillar tracks (Plates 3 and 4), but about five years ago a new type of excavator, known as the Walking Dragline (Plate 1), was introduced into this country from America. The particular feature of this machine, as its name suggests, is a walking device which replaces the usual caterpillar tracks. In addition to this the machine is mounted on a large circular base, 20–30 feet in diameter, which greatly increases its stability and enables it to be fitted with a longer boom than is normally attached to caterpillar-mounted machines. The walking dragline is also able to move over soft ground in which the caterpillar-mounted draglines normally become bogged. In this country the largest walking draglines are fitted with booms 150 feet long, but still larger machines with booms of 200 feet are in use in the large opencast coal workings of the U.S.A.

Tractor equipment, such as Scrapers and Bulldozers, has recently been used in the opencast coal sites in this country, and to a limited extent in the ironstone workings.

A Scraper consists of a steel tractor-drawn vehicle, usually of 6–12 cubic yards' capacity, mounted on large rubber-tyred wheels (Plate 5). The bottom of the vehicle is fitted with a cutting-blade which, when lowered, is dragged through the soil or overburden. When full the Scraper is transported to the

required dumping point where the material is discharged through the bottom of the vehicle in an even layer. Scrapers are particularly useful for stripping and re-levelling soil and soft material, but they are incapable of excavating beds of sandstone and limestone.

A Bulldozer is a high-powered caterpillar-mounted tractor fitted with a concave buffer-blade, 6–10 feet long and 2–3 feet high, fixed in front of the machine. As the tractor moves forward the blade levels the ground by pushing the material in front of it (Plate 6), and for this purpose it has been found particularly useful for smoothing out irregularities in the worked-out areas of opencast coal sites. It is a machine which could equally well be used for levelling the "hill-and-dale" formations which at present disfigure the countryside in some parts of the Ironstone Field of eastern England.

PRINCIPLES OF PHYSICAL GEOLOGY

PRINCIPLES OF PHYSICAL GEOLOGY. By ARTHUR HOLMES. *Edinburgh: Thomas Nelson*, 1944. 8×5½ *inches;* xii+532 *pages; illustrations and diagrams.* 30*s*

ALTHOUGH there are many excellent textbooks of physical geology and of geomorphology, ample room has been available for one incorporating the outstanding developments of the ten years preceding the war. Professor Holmes' object has been to provide such a book, and in so doing he has succeeded in producing a delightful blend of the old and new in a stimulating and readable form.

The scope of modern geology is very wide, having "for its aim the deciphering of the whole evolution of the earth and its inhabitants." It has many offshoots and strong ties with other sciences: it is linked through mineralogy and petrology (materials) with chemistry, through physical geology (processes and their effects) with geophysics and physics, and through historical geology (stratigraphy) with palaeontology and so with biology.

To Professor Holmes the whole "machinery of the earth," both observed and inferred, is the domain of physical geology. Much of this is the machinery of internal processes that take place deep in, or beneath, the outer crust. It is from the exploration of the inaccessible portions of the earth by the aid of modern physical methods that the most striking of the newer concepts and trends in physical geology have developed.

From the many exciting lines of research Professor Holmes describes mention may be made of the charting of the relief of the ocean floor by sonic sounding, gravity measurements at sea from submarines and amid the high plateaux of the continents, the core sampling of deep-sea deposits, and seismological investigation of active volcanoes. The contributions of such work to the fundamental aspects of earth science, and in particular their bearing on that most spectacular of hypotheses, continental drift, represent advances of a magnitude rivalling those of physics itself.

It is clearly recognized by the author that an intelligible picture of the probable significance of the latest research cannot be conveyed without reference to hypotheses involving highly controversial interpretations of the facts, or, to use Daly's phrase, "the pyramiding of ideas." To accomplish this in a moderate compass without giving undue weight to the speculative side of an inherently observational science is almost an impossibility. To some it will appear that

Professor Holmes has accomplished this feat; but to others more orthodox, it may seem that a student guided by this book might "know all about the interior of the earth and little about its surface processes."

Geographers will realize that at the outset Holmes is faced with a problem familiar to them; for most of them appreciate that a sound grounding in the principles of physical geology is essential to the study of geomorphology. Similarly physical geology needs a basis of general geology. Whether to build up in one textbook the basic framework for the study of earth processes and landforms, or, alternatively, to assume that the framework already exists, is a very real dilemma. Holmes has wisely devoted one-fifth of his book to his "Part I, Preliminary Survey." At the expense of some repetition this approach makes the treatment complete in itself, a major consideration for the uninitiated student and for the general reader. This also makes it an excellent introduction to the more systematic textbooks on geomorphology.

Part I covers the surface relief of the earth, its processes, constituent rocks and minerals, structure, and history. Two criticisms of small items may be made. First, Figure 7, "The circulation of meteoric water," which shows a movement from the atmosphere to rivers and glaciers and thence to the sea might advantageously show a return process. Secondly, it is stated (p. 73) that "the *axis* of the fold along any particular bed (about which the bed is folded) is the line of intersection of the axial plane with the surface of that bed." This definition, though geometrically sound, is a particular case of the general usage that the axis of a fold is the line of intersection of the axial plane with any other surface. Indeed, on Figure 27 (p. 74) the term axis is used in such a sense. Another, and possibly the most important, example of this usage is the surface position of fold axes as shown on geological maps for which the term 'axial line' is perhaps to be preferred.

Parts II and III, making up the main body of the book, deal respectively with external and internal processes and their effects.

Part II follows well-established lines. It includes sections on rock weathering, underground water (including limestone country), rivers and land-forms due to running water, glacial geology, desert processes and landscape, and coast scenery and the action of the sea. The treatment throughout is pleasantly informal with a smooth progression from one aspect to another and gives an impression of teaching by example rather than by precept. The abundant examples are carefully chosen and well illustrated: good British ones where available, but selected from a world-wide field where advantageous.

The concept of a cycle of erosion is one which belongs to systematic geomorphology rather than to physical geology and, since its application to particular cases is being increasingly recognized as being decidedly speculative, the author's limited reference to it in his examples is to be welcomed. Nevertheless one may regret the adoption of the Davisian normal (humid) cycle of erosion without reference to the challenge of the German school of Walther Penck which has received much attention from American workers, such as Kirk Bryan and von Engeln.

In the glacial section the view that drumlins were in general formed "several miles from the ice-front" is adopted. This seems to be a generalization from Penck and Bruckner's frequently reproduced diagram of the drumlin belt within the arcuate frontal moraines of the pleistocene glaciers of the Alps. Evidence in Britain and Ireland however clearly indicates that the moulding of the ground moraine dates from near the climax of the glaciation when the ice fronts were up to 100 miles or more distant. There is a noticeable absence of any reference to the work of Streiff-Becker and of Demorest on the variations of

velocity with depth in glaciers and ice-sheets. Their results together with those of Seligman and others have thrown much light on the mechanics of glacier motion, and are of considerable importance. The special processes and land-forms which characterize peri-glacial and cold unglaciated regions receive only scattered and rather inadequate treatment.

A vivid account is given of the processes that fashion desert and "semi-arid" landscapes. The formation of pediments is clearly described. While the author is justifiably restrained in his use of special terminology the *bolson*, or basin with no outlet, might well be accepted.

In the Work of the Sea the complex shore-line processes are concisely summarized. In accepting Daly's theory of the origin of submarine canyons as the only "reasonably satisfactory" one, the author seems too lightly to ignore its inherent difficulties. The adequacy of heavy, mud-laden bottom currents (generated by wave-action on the continental shelf during low sea-level periods of the pleistocene) as an erosive agent capable of incising in the continental shelf and slope channels that are 6000 feet deep and comparable with the Grand Canyon of Colorado is open to serious doubts. Moreover similar erosional features are known down to 6000 feet or more in areas where there is little or no continental shelf, as for example off Bogoslof Island in the Bering Sea. In this region other channels commence at the outer edge of submarine plateaux at depths of 2000 feet or more.

The last two chapters of Part II deal with Life as a rock builder and Life as a fuel maker. In the former the fascinating problems associated with coral reefs bulk largely, while in the latter the current opinions of the origin and constitution of coal and oil are refreshingly described. It is difficult to appreciate the justification for the selective treatment of these particular economic minerals compared with the merely incidental references to equally interesting subjects such as bedded ores, mineral vein deposits, water power, or saline deposits.

In the account of internal processes and their effects which forms Part III the author is very much at home among those profound speculative problems to the solution of which he has himself made fundamental contributions. It is well here to refer to his prefatory remarks that "the frontiers of established knowledge are soon reached, and what we see by peering beyond is merely interpretation and must on no account be confused with the solid facts of observation." His fellow geologists may well differ from his assessment of the weight of evidence. Thus in discussing the origin of the batholiths as due to the soaking of country rocks in "hot granitizing fluids rich in gases" many would demur to the statement that "every positive line of evidence supports this view." It must however be acknowledged that on many controversial subjects a simple path must be taken in a book of this kind. Whether that path eventually proves to be the direct way out of the maze, a roundabout route, or just one of many dead ends, must be left for further research to decide.

Commencing with the results of earthquake shocks as the key to the physical properties (and inferred composition) of the deeper layers of the earth's interior the story of internal processes passes to compressional mountain building. Here the development of the orogenic belts of Europe and the Appalachians, and the fascinating complexity of Alpine structures are in turn described. The remarkable investigations of gravity anomalies at sea by Vening Meinesz and his collaborators are attractively and simply related to crustal movements now in progress in the East and West Indies—an interesting example in which a common geological dictum is in some measure reversed and our knowledge of the past history of earth movement has provided clues to our interpretation of the present.

Professor Holmes gives a masterly exposition of the hypotheses of convection currents in the fluid sub-crustal regions, as applied to mountain building and, in a later chapter, to the theory of continental drift. More information on such questions as the reconciling of a density-zoned earth with deep-seated convection currents, would have been welcome.

In the excellent descriptive chapter on plateaux and rift valleys the main structural features of the western United States, Africa, and Asia in turn are clearly depicted and built into a general conspectus of quite remarkable conciseness. Here again another question, possibly at present unanswerable, suggests itself as to how it is that many large areas apparently peneplaned during Tertiary times can have been uplifted 4000–10,000 feet by epeirogenic movements in late Tertiary times and yet remain more or less isostatically compensated.

In dealing with volcanoes, a subject attractive to the student and layman alike, there is an unusually good and picturesque account of the principles that appear to govern their activity and distribution as well as much clear description, that is particularly valuable for readers in a country devoid of constructional landforms of volcanic origin.

The final chapter is reserved for continental drift, perhaps of all modern geological hypotheses the most striking and most vigorously contested. The author's logical approach to the subject is of interest. He points out that the chief criteria in the case for continental drift are, first, close linkage of the orogenic features, sedimentary sequences, and fossil faunas and floras of continents that are now far apart; and secondly, changes in the distribution of climatic belts in so far as they can be identified in the geological record. The evidence goes far to satisfy both of these criteria. Moreover as Holmes rightly says, the lack of an adequate mechanism applies equally to alternative theories such as "land bridges" across the oceans. At this stage the reader is led to a tentative search for a mechanism based on sub-crustal convection currents. Indeed, so attractive is the picture that one is tempted to recall Du Toit's recent list of ten or more fairly modern hypotheses, half pro-drift and half anti-drift, that have been advanced to account for the mid-Atlantic ridge.

A special comment must be made on the illustrations. Most of the text-figures are original drawings: they are clear, well-drawn, simple, and largely self-explanatory. The outstanding feature is the magnificent series of photographs to the selection of which a great deal of consideration has evidently been given.

It is noteworthy that factual and printer's errors are extremely rare (the Skiddaw Slates of Black Combe are omitted from Fig. 91) and that there is a good index in which the illustrations are included—a big improvement on listing them at the beginning. Selected references are almost entirely to books, but they might have been supplemented by a few original papers in readily accessible British journals. Printing and paper are good and show little trace of war-time utility constraints.

This book, notable for its simplicity of presentation and lucidity of style, represents a real achievement in the portrayal of geology as a science that is full of vitality and of intriguing problems awaiting solution.

S. E. HOLLINGWORTH.

SOME NEW EFFECTS IN MAP PROJECTION

THE textbooks generally agree that the Orthographic Projection is of value only in astronomy. Its adoption for all the principal maps in 'A war atlas for Americans' must lead to a revision of this opinion. A preliminary note on the maps explains that the Atlas is designed to make an acceptable substitute for the globe, which is inconvenient to handle, and expensive. The orthographic projection admittedly produces distortions in areas and shapes which increase in all directions from the point chosen as the centre, but "there is an illusion of depth and perspective which has many advantages for purposes of illustrating the topographical qualities of the areas shown."

Many of the maps are hemispheres; many of the others have at any rate one corner cut off by the bounding circle, even if the scale of the map and the size of the sheet require that the centre of the projection is outside the area of the map, as for example in No. 24. In these corners the radial scale falls rapidly to zero at the boundary: the last ten degrees occupy only fifteen thousandths instead of one-ninth of the radius; outlines become so flattened and indistinguishable that they give the foreshortening effect of looking at a globe almost tangentially. The area scale at the centre is correct; at the boundary it diminishes to zero, and this is economical because for a sheet of given size it allows one to show the more important central regions on a larger scale.

The maps are in two colours only: black for names, symbols, and numerical details, blue for the sea, rivers, and mountain drawing, leaving the lowlands white, except that towards the circumference the land also has a certain blue shading over it to hide partly the distortion, and to give a general effect of depth. Moreover, the blue sea in the middle of the map is often a little lightened, to give something of the effect of light reflected from a polished globe. All these devices combine cleverly to give a globular aspect to the flat map, a kind of birdseye view of a globe with the mountains in relief, necessarily exaggerated, and perhaps too much so when distant mountainous regions are drawn projecting beyond the circumference of the hemisphere.

The graticule of meridians and parallels is generally shown by white lines in the blue sea and not at all on the land. One may think that for any serious use of the Atlas the graticule should be complete, probably in blue lines over both sea and land; it would contribute something more to the globular appearance and make it possible to insert places not already indicated. One might also with advantage show a radial scale of miles, especially when the centre of projection is off the sheet and there is only a small arc of the circumference in one corner. Many of these maps cover two facing pages, which demands that the binding allow them to open flat.

This use of the orthographic projection in the War Atlas for Americans is not quite new. It has been seen since 1940 in the striking maps made by Mr. Richard Edes Harrison for *Fortune*. An original set of seven, in black and grey, was published by *Fortune* in September 1940 in the 'Atlas for the U.S. Citizen,' and others, in brilliant colours, have been included from time to time in later issues. These are now, with a few more, collected in a handsome volume 'Look at the World,' recently published in New York by Alfred A. Knopf, in a limited edition, of which we have been allowed to study a presentation copy.

In a spirited introductory article on The Geographical Sense Mr. Harrison discusses "the dilemma of having to depend on flat maps to show us parts or the whole of a spherical world," and says that "it seems to require a geographical sense to solve it." He believes that the convention that North be always at the

top of the page has been the chief obstacle to a flexible view of geography: it is "geographical cant in its most pernicious form." He has therefore drawn his maps from other aspects, and speaks of them as being perspectives, to be viewed from a fixed position of the eye. But he does not give us enough information to know what this position should be. The projection is presumably the orthographic, but the latitude and longitude of the centre are not given nor is the centre marked on the sheet. In any case, to get the true perspective from this projection it must be viewed from infinity, not from the distance of distinct vision which is about half the breadth of a double page map. The map gains a perspective effect from the use of the projection, but it is not in true perspective from any possible view point. A paper by Mr. Harrison on the use of Nomographs for making these projections was discussed in the *Journal* for May last, Record, p. 239.

If there is a sufficient arc of circumference on any one of such maps it is easy to find where the centre of projection is even if off the sheet. If AB is a chord subtending an angle 2θ at the centre, M the middle point of the chord, and PM the perpendicular to the chord from the middle point of the arc, then $AM/PM = \cot \frac{1}{2}\theta$, and the radius $R = AM \operatorname{cosec} \theta$. It will be worth while to find this centre for all maps on which it is not shown; but sometimes difficult, where the circumference is encumbered with mountains much out of scale.

To construct a radial scale of miles, which adds much to the understanding of these maps, we have for the International Figure of 1924 the mean radius 3958·9 statute miles and the quadrant of meridian of the sphere 6218·6 miles, which gives 500 miles = 7°·236, and 6000 miles = 86°·836 of the quadrant. If then R = the mean radius of the sphere on the desired scale, the distances from the centre are: 500 miles = R sin 7°·236; 1000 miles = R sin 14°·473, and so on up to 6000 miles = R sin 86°·8356 = 0·9985 R. By such simple additions we may add substantially to the use of these maps on the Orthographic Projection, thus re-established as of some geographical importance.

We have received by courtesy of the Geographer to the U.S. Department of State an interesting world map which has the general appearance of Mercator, though a glance at Greenland shows that it is not, and inspection of the parallels shows that the lines bounding the sheet north and south must represent the Poles, though they are not figured or lettered as such. The map has no title, and no indication of origin. An accompanying sheet printed in red is a graticule resembling in a general way the Transverse Mercator graticule. The instructions in the margin explain that it "is intended for use only on maps of the world constructed on the same scale on the cylindrical projection which was recently devised for the U.S. Department of State by Mr. O. M. Miller of the American Geographical Society of New York" and the diagram was also devised for the Department by Mr. Miller. There is no further explanation; but one remembers that in the *Geographical Review* for July 1942 Mr. Miller published some "Notes on cylindrical world map projections" which included four "compromise projections," Perspective Compromise, Modified Mercators (a) and (b), and Modified Gall. A little trial seems to show that the projection employed on the map of the Department of State is Mercator (b), of which the parallels are computed from $Y = (5R/4) \log_e \tan (45° + 2\phi/5)$ instead of by the standard formula $Y = R \log_e \tan (45° + \phi/2)$.

Some sheets of the map are printed on thin paper, with the intention that the map shall be adjusted over the red graticule to find great circles in the usual way, but this is difficult except on a tracing table. This modified Mercator has the

advantage over the normal that it allows one to plot a complete great circle passing near the Pole, instead of a great circle with a dramatic gap in it.

Those who have the good fortune to receive these sheets must be careful to mark them as belonging together; if they were separated there is nothing on either to show it belongs to the other, nor any reference to the Notes in the *Geographical Review*, from which the law of the projection may be discovered.

We have received also two very interesting small books. The first is 'World Maps and Globes,' by Professor Emeritus Irving Fisher of Yale University and Mr. O. M. Miller of the American Geographical Society's staff (Essential Books, 270 Madison Avenue, New York. $2.50). Its purpose is a general statement on the subject, mostly by illustrations, with the text as an accompaniment in non-technical language. There are 71 figures, mostly in two colours, and not a mathematical symbol in the book. The basis of the whole is a clever use of the regular solid the icosahedron, whose faces are twenty equilateral triangles, in symmetrical groups of five round twelve vertices. The icosahedron is inscribed in the sphere so that the polar axis passes through the centres of two opposite triangular faces, and the projection of the prime meridian is perpendicular to one side. The edges of the twenty faces, projected from the centre upon the enveloping sphere, make thirty equal arcs of great circles, forming twenty equal spherical triangles upon the sphere, each equilateral, with angles 72°, since five converge at equal angles to each vertex. It is easy to calculate the latitudes and longitudes of the twelve vertices, and to plot the triangles upon any world map. The resulting shapes are a most valuable indication of the general distortions of each projection: much more instructive than the usual figures of the scale errors at a number of points.

The book contains thirty-three small maps on the principal projections, of the whole sphere, or of a very wide belt of it (such as Mercator's) or of pairs of hemispheres, with the projection in solid black lines, the triangles in dotted lines (not always well distinguished when they coincide with lines of the graticule), the land surfaces in yellow. These make the most instructive commentary upon the merits of the several projections that one has ever seen, and the authors may be congratulated upon a brilliant idea. They do not give the coordinates of the twelve vertices and in these days American books do not readily come to the English market; so I have calculated the small table, for the use of those who will be interested at once to draw them in their own atlases: always remembering that the sides of the triangles must be drawn as great circles, which will give some practice in the use of Nomographs as described by Mr. R. E. Harrison in the *Geographical Review* for October 1943.

If the North Pole is placed in the centre of one of the twenty triangular faces of the icosahedron, and the meridian of Greenwich is perpendicular to one of the sides, then the twelve vertices of the icosahedron are

Three in latitude 52°.62 N., longitudes 60°, 180°, and 300° E. or W.
Three in latitude 10°.81 N., longitudes 0°, 120°, and 240°.
Three in latitude 10°.81 S., longitudes 60°, 180°, and 300°.
Three in latitude 52°.62 S., longitudes 0°, 120°, and 240°.

In the small diagram of Mercator's projection (Fig. 14), the first to show these triangles, the meridians are at intervals of 15° but are not figured. The central meridian seems to be 90° west of Greenwich and passes through a triangle vertex in 52° N. The three meridians which are perpendicular to the sides of the polar face would then be 30°, 150°, and 270° west. Many of the diagrams have the same triangles, but others, Nos. 19, 22, and 23, have not, and it is not

necessary. The above table serves for any prime meridian which may be found convenient.

There are some large globes in the United States, of which photographs are given, and a chapter on Shadow Maps begins with Photographic Projection, which seems to be perspective projection of the convex globe, upon a plane from a point relatively near. This is "often used in magazines and newspapers" and Fig. 20 is such a drawing made by Mr. Richard Edes Harrison, but it remains uncertain whether he has used such photography in his maps for *Fortune*. There is no mention of any relief globe in the United States.

Chapter Seven deals with maps which may be folded or wrapped into an approximation to a globe, such as the gnomonic projection upon the icosahedron, already discussed, or the Dymaxion of Mr. R. Buckminster Fuller on the six squares and eight triangles drawn by Albrecht Dürer four hundred years ago: they make a solid, but not a regular solid. It was published in *Life* of 1 March 1943.

An International Committee on Meteorology recommended in 1937 a "near-globe" composed of two polar planes, an equatorial cylinder, and two intermediate cones, which could be used flat for plotting, and then mounted on a very necessary solid to make a pseudo globe, designed by Mr. A. C. Clark of Pan-American Airways. The Coast and Geodetic Survey have made a near-globe from the six belts of conical projections on which their Air Force charts are plotted. And Professor Fisher described in the *Geographical Review* for October 1943 a world map made by gnomonic projection on the Icosahedron, but not that earlier described: the poles are at two vertices of the solid, instead of in the centre of two parallel faces. The author is kindly presenting a specimen of this near-globe to our Society.

The second book is 'The geography of world air transport' (The Bookings Institution, Washington. $1.00), by Mr. J. Parker van Zandt, who has an appendix, Map Projections and the determination of great circle courses, in which he describes as new what is the ordinary nomograph method of sketching these courses and measuring their length. His proposed technique is to draw the nomograph on a transparent sheet of non-shrinkable plastic material, with perforations at intervals through which a pencil point may be inserted. "That is all there is to the device, a pin and a piece of plastic," and a "convenient gadget" one can use with any map. But this is a little optimistic, if only because the gadget must be on the same scale as the map with which it is to be used. That is the snag in all nomograph methods: one must work to the scale of the accurate nomograph, or else make a nomograph for the scale of the particular map to be produced. In any case it seems better to use a piece of tracing-paper or plastic as an intermediary between the oblique map and the accurately engraved nomograph, rather than try to draw the latter on the plastic.

The most interesting thing in the book is the sketch of a Principal Hemisphere. Penck calculated in 1899, and Raisz confirmed it in 1943, that the hemisphere with the greatest land surface in it is centred on a point south-east of Nantes. The hemisphere centred on this point includes the whole of North America, the whole of Asia excepting the Mekong peninsula, and the whole of Africa. The shortest way between any two points in this hemisphere never leaves the hemisphere; the Pacific lies almost wholly in the other half of the world, and so will not figure prominently in the trunk air routes of the future. And few major air routes will go as far north as the Arctic Circle; most of the over-the-pole routes would be little more than short cuts to nowhere. This Principal Hemisphere, sketched by Mr. van Zandt on p. 6 of his book is a

valuable discovery. One knew that the western coast of America and the eastern coast of Asia lay close to a great circle, but so far as one knows it had not been observed before that these coasts were just included in the hemisphere centred on Nantes, leaving almost the whole of the Pacific Ocean in the opposite hemisphere. This Principal Hemisphere of Mr. van Zandt has its centre in 47° N. 11° W. The hemisphere for the Pacific shown in the Discussion on the Map of the Pacific (*Journal* 100 (August 1942) 71), had its centre in 35° S. 2° W. about 11° from the antipodes of the first, and just missed the point which Mr. van Zandt has made so well. One would like to see his hemisphere drawn accurately upon a larger scale.

Such are some of the new effects in cartography achieved by our American Allies to meet the requirements of global warfare and world air travel. The small book by Irving and Miller, and the large atlas of War Maps for Americans, which contains an admirable account of the military operations since the outbreak of war in 1939, are of especial interest. A. R. H.

REVIEWS

EUROPE

ANGLO-SAXON ENGLAND. By F. M. STENTON. (The Oxford History of England.) *Oxford: Clarendon Press*, 1943. 9×6 *inches;* x+748 *pages; maps.* 21*s*

Professor Stenton has succeeded in the difficult task of surveying the five hundred years of the turbulent and obscure history of Anglo-Saxon England within the limits of a reasonably sized volume. He has assembled a mass of detail into a coherent whole, in which generalizations and the particular instances which enliven such studies are skilfully balanced. The scope is wide, the main themes dealing with the evolution of political unity, the introduction of Christianity and the development of the Church as a social and cultural organ, and the intricacies of the legal system. As a summary of present knowledge of the period, it will appeal to the general reader, and the extensive references and the annotated bibliography make it valuable to the student.

The student of historical geography will find much of interest, though the geographical background is not specifically described. The details of the earliest settlements are necessarily obscure; there is a brief reference to the preference of early colonists for river valleys rather than for the heavy wooded clays, and to the later clearing of these. The prevalent form of settlement in the south and south-west is shown to have been the village, associated with a definite area, a multiple of five hides, each commonly considered to support one family, but scattered Anglo-Saxon farms, struggling amid unfavourable conditions are found at an early date. The importance of woodland in medieval economy is illustrated by the reference to the association of stretches of woodland pastures with particular manors.

There are also some interesting details on the early history of the towns. The site of London was apparently never abandoned completely, but the early Saxon settlement had little significance, and its later importance was due largely to its part in the resistance to the Danes. By the ninth century, Rochester, Canterbury, Southampton, and York had also become important centres. Two

centuries later, many county towns had sprung up; these fulfilled three functions; as agricultural units, linked to the countryside by manors with their town houses, as trading centres, and as places of defence. Their organization not only protected the trader's goods, but guaranteed the legality of his transactions. Most of these county towns were established on royal lands by the initiative of the king; the tenants were personally free, and the king met the cost of defensive works from rents and dues.

The closing chapters discuss lucidly the significance of the Norman Conquest, when a foreign aristocracy organized effectively for war imposed its rule ruthlessly, but displayed much political wisdom in adapting native institutions. In rural life the conquest marked the final stage in the substitution of the authority of the lord for that of the community. G. R. C.

ASIA

THE U.S.S.R.: a geographical survey. By JAMES S. GREGORY and D. W. SHAVE. *London: George Harrap*, 1944. $7\frac{1}{2} \times 5$ *inches;* 636 *pages; illustrations and sketch-maps.* 21*s*

THE U.S.S.R.: an economic and social survey. By S. P. TURIN. *London: Methuen*, 1944. 9×6 *inches;* xiii + 219 *pages; sketch-maps and diagrams.* 16*s*

There has long been a need for a comprehensive and systematic survey in English of the geographical background to the Soviet Union as an aid to a truer understanding of Russian life and problems. Hitherto there has been only Mikhaylov's 'Soviet geography' as a guide for British readers, and although this book has its own interest and quality, its very enthusiasm for post-revolutionary achievements prevents it from becoming a straight-forward balanced introduction. It is both fortunate and timely therefore that we are now being provided with objectively written studies of the Soviet Union such as the two works noted above.

Gregory and Shave's work fulfils its purpose as a geographical survey of the whole Soviet Union at the time of the German invasion. The contents and arrangement of the book follow the familiar pattern of university geographical texts. About one-third of the book is devoted to the physical elements of the U.S.S.R., and there is briefer reference to its history, nationalities, administrative divisions, and agricultural and industrial development. Much the greater part of the book is concerned with the geography of the major regions of the U.S.S.R., with short considerations of transport, population distribution, and the U.S.S.R.'s position as a world power. Gregory and Shave have achieved some success in their ambitious task of outlining the major geographical features of what is still a rapidly changing scene. Changes, particularly during the last twenty-five years, have transformed the human as distinct from the physical geography of Russia as it was described, for example, by Reclus two generations ago. The main change, accentuated by the present war, has been the colonization and economic development of the Volga, Urals, and eastern regions, so that the loss of the Ukraine and the neutralization of the Leningrad industrial region in 1941 were not crippling blows to the Soviet Union.

Gregory and Shave have made good use of the more readily available Russian material such as N. N. Baransky's 'Physical geography of the U.S.S.R.,' which was written for schools, some translated passages from which might well have been acknowledged in inverted commas. They have been very generous in giving the latest available pre-war statistics—for example those of the 1926 and 1939 censuses, 1938 sown areas, etc. There are numerous sketch-maps: among the best is Fig. 25 on coal distribution, and among the less satisfactory, since

it contains several errors, Fig. 26 on pig-iron production. Inevitably in a generalized survey of this kind there are a number of slips: there is no nickel at Nikopol (p. 240); on p. 246 the reference should have been not to synthetic rubber plants but to fabricating plants at Leningrad, in the Urals, and possibly in Eastern Siberia; Kharkov, rather than Khabarovsk, had a giant tractor plant (p. 247), and Komsomolsk, not Khabarovsk, is the new steel centre in the Far East (p. 343), though hardly on the scale of the 600,000 tons suggested (p. 240).

Gregory and Shave's picture of the U.S.S.R. relates mainly to the pre-invasion years, and the reader must make his own allowances for the heavy destruction which Soviet industry and agriculture have suffered, notably in the Ukraine. This is not to say that these authors have not noted some of the more recent developments in Russian industry and transport: the economic development of the Pechora region, for example, will probably be new to British readers. Attention is also given to Soviet industrial development in the East, but it is something of a speculation as to whether, as the authors suggest (p. 608), China may ultimately benefit therefrom.

Dr. Turin's work consists mainly of an exposition of, and a commentary on, the pre-war population, production, trade and other statistics of the U.S.S.R., which usually include 1913 figures as well as those between the years 1928 and 1937. This book is not directed solely to students of geography, although such may be interested in the scheme of economic regions of the U.S.S.R. devised by Gosplan (at some date unspecified) which Dr. Turin has followed in Part II. They may find helpful too his diagrams showing the administrative and political structure of the Soviet Union (pp. 193 and 195). Students will however be somewhat confused in reading Chapter IV, Economic Regions, by the fact that the administrative divisions, *krais* and *oblasts*, given here have for the most part disappeared from the present map. The book is in some respects unsatisfactory and the sketch-maps often have little to tell. On p. 43 "18·3 %" in the text should read "13·8 %"; the section on iron and steel (pp. 124–5) omits consideration of pig iron and steel; some of the paragraphs on non-ferrous metals (*e.g.* on tin and aluminium on pp. 127–8), including the production figures, are misleading. The table of river basins on p. 33, with the Lena draining into the White Sea and the Pechora into the Sea of Azov, together with the phrase "Omsk region (Akmolinsk)," on p. 127, appear to start new geographical heresies. W. G. E.

THE ACHIEVEMENTS (USPEKHI) OF GEOLOGICAL AND GEOgraphical Sciences in the U.S.S.R. during 25 years. Edited by V. A. OBRUCHEV. (In Russian.) *Moscow and Leningrad: Academy of Sciences*, 1943. 9×6 *inches;* 200 *pages*

This book is so concentrated that it is difficult to make a short summary of it. In the introduction, to bring home to us the growth of these studies, the editor, Acad. V. A. Obruchev, tells us that in 1914 there were two hundred and fifty to three hundred trained geologists, whereas at the International Geological Congress in Moscow, 1937, there were one thousand five hundred Soviet geologists present. The amount of work referred to is colossal, though of course the same names recur again and again. The reviewer has noted the names of about thirty institutions having some relation to Geography. These institutions however have not all existed at one time; they are continually being divided and amalgamated, reorganized and decked with new names, mostly prodigiously long and cut down into puzzling abbreviations. In the essays references to individual articles are not given and the bibliographical indications are very vague.

The book is mainly geological, but there are papers which concern geography,

such as studies of Quaternary geology and applied geophysics; also the study of permanently frozen soil, estimated by Sumgin at 33,000,000 square kilometres or 22 per cent. of the land surface of the globe, a third of it in U.S.S.R.

Throughout the book there is a tendency to run down work done before 1917, especially in geology. All through the twenty-five years the practical purpose of the studies has been very much stressed, and this book brings before us the enormous discoveries of coal (the area is now eight times as much as that known in 1914, more than half in Permian, a quarter in Jurassic, and less than a tenth in the Carboniferous), oil, shale, gas, iron, copper, tin, tungsten, gold, bauxite, and what the Russians call *polimetally*. In the Il'men mountains, south of the Urals, they have made a mineralogical reservation, as the area contains one hundred and fifty minerals, some peculiar to it. They have also three great museums: the Chernyshev Geological Museum and the Mining Museum in Leningrad, and the Karpinski Geological Museum removed from there to Moscow.

The long article by Nalivkin on Stratigraphy, and that by the editor on Tectonics are two of the most interesting in the book. A. A. Grigoriev writes at length on Geography, mostly rehearsing his own contributions. He is specially concerned with refuting Hettner as representing "bourgeois" geography, which he regards as too abstract, narrow, and static, and in developing his own ideas of geographical processes. At the end he does notice the special studies of Soviet geographers, but apparently does not mention the most surprising discovery of all, the almost Alpine Cherski chain between the rivers Kolyma and Indigirka in north-east Siberia. E. H. M.

STRUCTURE AND EVOLUTION OF PALESTINE, with comparative notes on neighbouring countries. By LEO PICARD. *Jerusalem: Geology Department, Hebrew University*, 1943. 9×6 *inches; 136 pages; sketch-maps and diagrams*

This book on the geology of Palestine is a welcome publication, as it assembles in convenient form a mass of data accumulated over many years. Palestine is such a small country that to be properly understood it must be considered with its neighbours. Professor Picard presents enough of the story of contiguous countries to allow Palestine to be viewed in perspective. As is his wont the author is not content with a statement of fact, but interweaves speculation and theory throughout the work in such a way that the reader is occasionally roused to criticize—but is sometimes only befogged. This may be partly because the language is not idiomatic English, and should there be another edition it could be much improved. The volume is worthy of better illustrations and should be accompanied by a good map. It is sometimes difficult to follow the argument because places named are not shown on the 1/M map, which is the only one the average reader is likely to have access to, and the structural map, Fig. 1, is not very clear. The first part of this book deals with structure and the second with historical geology.

Part one commences by describing the lowlands or depressions, largely the product of faults and tilted blocks, and then goes on to an account of the folds. A valuable figure (Fig. 2) provides a clear picture of the arrangement of these from the borders of Sinai up to the boundary of Syria, and fourteen pages of text augment the simple profiles. The country is divided into three longitudinal parts: the coastal plain on the west, the hilly region in the centre, and the Tiberias–Jordan–Araba valley on the east. In the north, beyond Nablus, there are many oblique faults as well as the main longitudinal ones. The main faults run north and south and are responsible for the eastern valley, and another

group of them may occur in the west and let down the coastal plain, but this cannot be proved. A second series is aligned north-west and south-east, and a member of it controls the low land which runs south-east of the Bay of Acre, a prominent feature in northern Palestine. A third lot run north-east and south-west, and initiate several smaller valleys. Tilting of the blocks between them has had some topographical effect. South of Nablus gentle folds are evident and some of their component sheets of rock are exposed, the older ones in the core of arches and the younger ones upon the flanks, except in the north, where the faulting is prevalent. Each dome is discussed in some detail and attributed to folding which occurred in Middle Tiertary times, although warping, which occurred later, and faulting, which started in the late Tertiary and continued to be active through the Quaternary, has also played a large part in shaping the landscape. The author ends this section with a discussion of the rather specialized usage of certain terms employed, his case being that the arrangement of folds and fractures in Palestine is abnormal because it stands on the northern edge of the Arabian land mass.

The story opens in the second part with an account of mountain-building and volcanic activity in pre-Cambrian days and of the prolonged erosion following them. This produced an extensive plain which, during the years that followed between Cambrian and Oligocene times, suffered gentle uplifts and depressions but no folding. As a result it was sometimes the scene of a desert and at others of a shallow sea. Sediments of both types accumulated and are intercalated. The desert phases accounted for the Nubian sandstones; the marine for the thin limestones and marls. The edge of the Arabian continent crossed Palestine and the shelf gave way to deeper sea north-westwards. Consequently the relatively thin shallow-water beds and desert deposits of Arabia are represented in Syria by thick limestones and marls of various ages from Jurassic onwards. Nearly 7000 feet of marine sediments were laid down in Judea between Cretaceous and Oligocene times, the whole column having been built up layer by layer without perceptible folding. The depth of water varied and the edge of the desert was far away or near at hand in response to vertical movements of the land, the only movements to occur throughout this very long interval. This state of affairs was brought to an end in the Lower Miocene by the compression which produced the flexures that can be seen to-day, and soon after it faulting broke up the country when the inland basins were produced. Either faulting or folding about the same time gave rise to the low country in the west of Palestine forming the coastal plains. The inland basins have collected gravel and sand from the hills on the one hand and from the plateau on the other. They accumulated in late Tertiary and Quaternary times to a thickness of about 2000 feet. The basins have also been flooded by lakes when a wetter climate prevailed, but as the region became drier the water retreated into separate bodies, leaving the rest of the area covered with layers of mud and gypsum. Lava was also erupted over them near the northern end of the long basin. Still later the river connecting Lake Huleh with Tiberias and the Jordan, linking Tiberias with the Dead Sea, cut through part of these deposits, and now flows in a long narrow valley. The stages which led to the formation of the present Dead Sea are many, but they are crowded into very late geological time. The author suggests that movements along north and south faults may have continued as late as historic times and may be connected with the story of Sodom and Gomorrha. The extreme saltness of the Dead Sea is regarded as probably due to evaporation of water fed by mineral springs and of streams flowing into the Jordan. On the west of the Judean hills coarse debris is also piled up thickly on the coastal plain, which, like the Jordan valley, has been subjected to several

oscillations. Sometimes the sea has flooded much of it; at others it has been lifted up. The history of this region has been revealed as a result of drilling. The author makes a strong case for a long period of aridity in the Jordan valley, and rejects the view that a tropical climate existed here in the Quaternary.

The book finishes with a short summary and a full bibliography, but, although there is a list of contents, there is no index. There are a number of little block diagrams which serve to emphasize the points as they are made. The book is a notable addition to geological literature of the Near East. J. V. H.

CENTRAL AND SOUTH AMERICA

CENTENARIO DEL AMAZONAS: LA EXPEDICION DE ORELLANA y sus problemas historicos. By EMILIANO JOS. (Four reprints of articles from *La Revista de Indias*.) *Madrid: Graficas Yeguas*, 1942 *and* 1943. 10×6½ *inches;* 50+38+50+48 *pages; illustrations*

Don Emiliano Jos is a well-known worker in the field of Spanish-American colonial history, and a valiant protoganist of the enterprise and courage of Spaniards. The four reprints under review form a survey of sources of information concerning the earliest European explorations, records, and charts, of the Amazon, and certain other South American rivers. The illustrations are almost all reproduced from early reports.

Señor Jos presses the claim of Spaniards as the original discoverers of the Amazonian region, but his work is chiefly concerned with mention of, and a running commentary upon, "the precursors and successors of Orellana"; he names many writers, from the time of discovery onwards to the present day, who have left historical records, published or unpublished, and states the present whereabouts of such works.

This bibliographical summary was written as the basis for a projected volume of wide scope, and meanwhile will no doubt be found useful by students of an extremely interesting period in South American exploration. L. E. J.

POLAR REGIONS

PLOWING THE ARCTIC. By G. J. TRANTER. *London: Hodder and Stoughton*, 1944. 8×5½ *inches;* 256 *pages; illustrations and end-paper sketch-map.* 12*s* 6*d*

This is a disappointing book. It sets out to describe the voyage of the *St. Roch* from Vancouver through the North-West Passage to Halifax in 1940–42. The *St. Roch* is a Royal Canadian Mounted Police auxiliary schooner of 80 tons, and since her first commissioning in 1928 has been, as on this voyage, under the command of S/Sergt. Henry Larsen. In 1940 Larsen and his small party of seven departed from their usual patrol work, and an attempt was made to work the ship through the Canadian Arctic archipelago. It succeeded, and Larsen and his men now have the distinction of having been the first men to sail a ship through the North-West Passage from west to east. The only other occasion on which a passage has been made was when Amundsen took the *Gjoa* through from east to west in 1903–1907.

The present book, though not labelled as official, may possibly be the only account of the voyage available to the general public. If this should be so it will be unfortunate, as the author was not himself a member of the party, and has set himself to work up a narrative on what might be called literary lines. Dates are almost entirely absent. There is no definite statement of where the second

wintering took place. A photograph wrongly states it as being at Walker Bay, and readers will only with difficulty find the clues which establish it as at Pasley Bay. Dialogue has been introduced when possible and with amusing results, and more than one member of the crew is made to appear either foolish or faint-hearted. Phrases such as "the young voice was undershot with hysteria" and "'Nobody ever told me what beset with ice meant!' The voice that spoke was stretched taut with fear" can hardly be typical of members of the R.C.M.P. on Arctic patrol.

It is distressing to see a first-rate expedition treated in this way, and it is not perhaps too much to hope that a better account may be forthcoming. Larsen's own unassuming straightforward log, of which one or two extracts are given, would in fact make much better reading. J. M. W.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

LAND, AIR AND OCEAN. By R. P. Beckinsale. *London: Duckworth*, 1943. $7\frac{1}{2} \times 5$ *inches; 408 pages; illustrations and diagrams.* 15*s*

This book is intended for the general public as well as for physical geographers at universities and training colleges. It aims at ellucidating "problems which the author has found from experience to puzzle the average student." The general idea of the book is interesting, but throughout fundamental principles are frequently not asserted, and the text is somewhat overweighted by examples. This might have been avoided had the author adhered more closely to his promise of taking most of his examples "from the British Isles in the hope that the terrain, if not already, will in the future be known to the reader."

The book is divided into four sections, dealing with the Terrestrial Globe, the Atmosphere, the Oceans, and the Land Surfaces. In the first section the author draws attention to a lack of data about the origin of the oceans and continents and leaves the reader unaware of the attractive hypotheses put forward, and the vigorous researches that have been made in this field during the past decade. A failure to distinguish between facts and speculative inferences is noticeable in his description of the interior of the earth and his treatment of the theory of continental drift.

The section dealing with the Atmosphere is clear and readable, and the chapters on climatology are among the best in the book.

The third section, dealing with the Oceans, contains much that is of interest, as, for example, the statement that "the quantities of mineral salts present are enormous, and if they are withdrawn, sea-level would fall by about 100 feet" (p. 154). The random choice of repetitive examples tends however to make this part of the book tedious in places.

The final section, The land surfaces, occupies nearly half the book, but it falls short of the standard to be expected from such a publication. While much is said of crustal movements in many parts of the world, little mention is made of the interesting geological structures in the British Isles. Modern volcanoes are adequately described, but volcanic episodes which have occurred throughout geological times in this country are scarcely mentioned. In dealing with snow and ice as agents of denudation, Mr. Beckinsale is convincing as fundamental principles are clearly described and examples judiciously chosen.

Much of the criticism of this book undoubtedly arises out of the attempt to write an account of the "physical processes by land, sea, and air" which will serve the rather difficult dual purpose of a text-book for the student and a popular book for the layman. There are a number of good plates, but the line-block diagrams are rather crude in design and execution. W. D. E.

GENERAL

THE CHICHESTER SUN COMPASS. By FRANCIS CHICHESTER. *London: George Allen and Unwin*, 1944. *Sun compass with instructional booklet of 8 pages in cloth case* 5½×6 *inches*. 5*s*

The Chichester Sun Compass is, first a cardboard disc with a series of date groups on the circumference, and of symbols of the sun arranged in an eccentric curve and tied to the marks defining the dates by lines which are inclined to the radii, and thus take account of the mean equation of time for the group. This card is rotated beneath a transparent diagram, of which the circumference is divided into hours with twenty minute intervals, and within has a series of azimuth curves, at 10° intervals, figured from 60° to 300° from N. by E. The index of the date group on the rotating card is set to the local mean time on the transparency, and the azimuth of the sun-symbol which is tied to the proper date group is estimated to one degree by interpolation between the azimuth curves. All this is not a compass but a calculator. When the sun's azimuth is thus calculated the compass diagram on the back may be set to the sun, and other bearings read from it.

The author finds that the worst error which can come from using the same sun-symbol over the date group so large as from June 1 to 21 is less than two degrees; between these dates the equation of time varies 3½ minutes. Between September 1 and 21 it changes nearly twice as much, but this period is broken into three groups. The azimuth curves are calculated for latitude 52½° North, and, if used at mid-summer three degrees north or south of this, the sun's bearing may be given so much as 3° wrong.

The very brief description of the instrument and how to use it might be enlarged with advantage, and corrected in the paragraph of seven lines describing the method of setting the Compass Rose on the back when the sun's bearing has been calculated from the front. We are told to place a pencil upright outside the degree circle so that the sun's shadow falls on the centre of the rose, and *then* to rotate the rose until the shadow cuts the degree scale at the desired division, which must be on the sun side of the centre. One should be told to erect the pencil at the sun's bearing on the degree circle, and rotate the card until the shadow of the pencil falls across the centre. The card is then set, and may be used for finding other bearings.

The instrument should be redesigned. In the example sent for review the heavy circumference circle of the transparency blocks out the date scale, and the sun-symbols often obscure the figuring of the azimuth curves. The numerals are of the illegible kind beloved by instrument makers. A. R. H.

GENERALS AND GEOGRAPHERS; the twilight of geopolitics. By HANS WEIGERT. *New York: Oxford University Press*, 1942. 8½×5½ *inches;* x+274 *pages*. 12*s* 6*d*

GERMAN STRATEGY OF WORLD CONQUEST. By DERWENT WHITTLESEY and others. *New York: Farrar and Rinehart*, 1942. 8×5½ *inches;* xiv+299 *pages; sketch-maps*. 17*s* 6*d*

Dr. Weigert disentangles from the voluminous, scattered, and, as he maintains, deliberately obscure writings of Karl Haushofer the fundamentals of a grandiose plan for world dominion. The sources of Haushofer's theories were curiously diverse. His geographical determinism and his belief in the dominant role of the great spaces, or continents, in the future of the world were based upon Ratzel's theories of space and nation and Kjellen's conception of the state as a biological organism. His Spenglerian attitude to the fate of western Europe and

the future role of Russia led him to adopt wholeheartedly Mackinder's idea of the "heartland," as first set out in "The geographical pivot of history." Fitting all this together, he urged the necessity for Germany to control, or at least co-operate with Russia. His own observations in the Far East imbued him with enthusiasm for Japan, so that his final plan for world domination envisaged a German–Russian–Japanese block. This brief outline does not do justice to all the ramifications of Haushofer's geopolitics, compounded of sound observations and subjective theories which the author patiently traces out. Many of the arguments were influenced by contemporary conditions: his attitude towards Japan, for example, was largely stimulated by a desire for revenge on the western colonial powers. Mainly owing to his deterministic attitude he largely overlooked psychological considerations: in his theories power politics were dominant, and national ways of life neglected. There is a strange and significant reluctance to consider in detail the reaction of the North American continent to this world-embracing strategy.

Far from being the so-called "master plan" of German strategy in this war, Haushofer's plan has suffered at least two devastating blows, the assault on Russia, and Japan's entanglement in war with China, which he viewed with disquiet from the first. Certainly up to the present geopolitics has had little success in foreseeing, much less predetermining, the course of history. Incidentally his writings contain some penetrating forecasts of the difficulties which an invasion of Russia would encounter. Dr. Weigert believes however that Haushofer is still influential in German military circles, and that a military government would tend strongly to his views.

Dr. Weigert appears at pains to detach Haushofer's philosophy from the earlier trends of German history; he places much stress on the special and peculiar atmosphere of Germany and Munich after 1918, and dissociates earlier German political geographers from the inter-war geopoliticians. Mr. Whittlesey advances many arguments to demonstrate the continuity of German policy. He is less concerned with Haushofer individually than with his followers, the general background of the movement, and the means taken to popularize expansionist policies. The result of his work is to demolish effectively any claims geopolitics may have to be regarded as a science. The argument of the book is supported by numerous careful translations from a wide variety of sources.

G. R. C.

THE GEOGRAPHICAL BASIS OF GOVERNMENT specially applied to New South Wales. By J. MacDonald Holmes. *Sydney and London: Angus and Robertson*, 1944. 9½×7 *inches;* vi+168 *pages; illustrations and maps.* 12*s* 6*d*

This important work, by the Professor of Geography at Sydney, is in two parts. The second part presents the results of numerous field studies carried out over a period of years. In successive chapters he describes succinctly, but at the same time convincingly and with a considerable wealth of documentation, the landforms (including coastal types) of Australia, the tree-type regions of New South Wales, and the regional characteristics of the same State. The whole section is a model of geographical method which most geographers could study with profit.

Of the first part of the work it is not so easy to write. It deals with the much-debated borderland between Geography and Economics, between planning and politics. Doubtless there are some who will say that it is not the business of the Geographer to outline "a fresh approach to the meaning of Government." Holmes however thinks differently: for him, as for Strabo, geography exists to

serve the needs of the State. Accordingly the geographer must be willing to play the role of architect as well as surveyor. From this premise he proceeds to argue that before the foundations of a lasting peace can be laid, individual nations, and small communities within nations, "must make a fresh study of the qualities of their geographic environment and seek there a new wealth and a reorientation of their endeavour to a nobler purpose." How this reorientation can be achieved in Australia in general, and New South Wales in particular, with the help of an enlightened, geographically-minded government forms the substance of the first seven chapters.

Briefly, Holmes' thesis is as follows: that Australia should contract to supply abundant food and raw material for the world's use and to receive in return freedom from coercion in the matter of immigration. Thus freed from the threat of war, with all that that would mean in terms of security and easing of taxation, she would be able to concentrate on the development of her at present ill-administered rural areas, thereby paving the way for the absorption of a largely increased immigrant population—"up to a possible doubling in the near future" of the present figure. This proposition is then elaborated along regional lines, for the author contends that it is only by thinking and planning regionally that the fuller life characteristic of the capital cities can ever be established in the smaller townships and backblocks of the continent. To this end he proposes, for New South Wales, the formation of regional councils "with plenary powers in all that logically can be said to belong to the region"; the limits of the regions being delineated by him in the second half of the work. Only by the cooperative efforts of a limited number of people, such as would be possible in an area small enough to have community of interest, and for the men in authority to feel a personal interest in the lands they are administering, can "functional harmony" be restored, waste lands be rehabilitated, new resources be developed, and a right sense of civic responsibility and pride become inculcated.

Professor Holmes knows his subject and he makes many good points, but there are times when the reviewer could have wished for simpler language. Unlike the second part of the work, the first part is written in a highly ornate and wordy style which adds nothing to the propaganda value of the work.

G. H. T. K.

THE MONTHLY RECORD

THE NATURAL RESOURCES OF GREAT BRITAIN

Three Cantor lectures on "The natural resources of Great Britain" are published in the *Journal of the Royal Society of Arts* for 15 September 1944. Two were given by Dr. E. B. Bailey, one by Sir William Halcrow.

Minerals. By E. B. Bailey

This broad survey of our minerals is enhanced by the inclusion of many intriguing and far-sighted suggestions concerning their description and exploitation. When dealing with the formation of anthracite in South Wales Dr. Bailey makes suggestions which will cause some surprise among orthodox researchers. He suggests that the main loss of volatiles in the coals occurred during earth-movements, and that the seams in the eastern and southern parts of the coalfield escaped anthracitization through the unloading of those areas by erosion which roughly kept pace with the elevation of the coalfield. The sediments denuded from these parts of the coalfield were discharged through what is now the upper estuary of the Severn, into a great hollow of subsidence east of the Malverns. "On the west and north sides of the basin the uplifted rocks may not have been similarly eroded until a later date, but for the time being may have stood blanketed by detritus, delivered from the broad summit region of the adjacent Welsh mountain-land, which we know was undergoing a more or less simultaneous renewal of uplift." Objections to these suggestions will naturally be forthcoming: the deeply buried Kent coalfield and the concealed parts of the Yorkshire coalfield do not contain anthracitic coals. Even though this hypothesis of differential loading may not appeal to some geologists, its originality will provoke much valuable discussion which may lead to the solution of the problem of anthracitization.

When dealing with the great wartime project of working coal in opencast pits, Dr. Bailey philosophically remarks that "we live in days when expense of output is reckoned in man-power rather than money." He is hopeful of the possibilities of underground production of gas from coal in this country. The idea was initiated by Sir William Ramsay in 1912, and since then extensive and successful experiments have been carried out by the Russians. We still await however the full account of the results of their work, which will undoubtedly influence the development of some of our coal resources.

Dr. Bailey outlines the search for oil in Great Britain. Geophysical methods developed in Persia in pre-war days were applied to the intricate problem of locating small anticlines in the Carboniferous rocks deeply buried beneath Mesozoic formations in eastern England. These structures, some of which yield oil in reassuring quantities, were quickly proved by drilling outfits which sank boreholes to depths of over 5,000 feet at the amazing speed of over 500 feet per day. On the nature of the source-rock for oil he remarks that "coals have not been important source-rocks, for most oil and gas are drawn from marine assemblages of strata devoid of intercalated coal seams."

In his description of the iron and steel industry Dr. Bailey clearly indicates the reasons for the exploitation of our low-grade bedded iron ores, particularly those which occur in the Jurassic rocks of eastern England. When dealing with the formation of our non-ferrous minerals he urges workers not to attach too much importance to the "bulk temperature of the country rock bounding the channels of ore deposition. If an ore-bearing solution flows fairly rapidly its temperature at any point may be largely determined by the time taken on its journey from the distributing centre." He also suggests that ore-bearing

solutions cannot be expected to penetrate thick deposits of clay unless they are propelled by "something of the violence of a volcanic outburst."

Underground waters. By E. B. Bailey

Water will undoubtedly play an ever increasing part in our industrial progress. It is replenished from time to time, but Dr. Bailey has drawn attention in many places to the need for eliminating wastage. In some places, particularly the London area, the replenishment of underground sources of water falls short of the amount pumped out from wells and boreholes. The cumulative effect of pumping water from the chalk below central London for a century has caused a general depression in the water-table to more than 100 feet below sea-level. Dr. Bailey also draws interesting comparisons between the allocation of water to town and country dwellers. Figures are given to illustrate the supplies of water to dairy farms, horticulture as in the Lee valley, and to hydro-electric schemes throughout the country. Altogether it has been estimated that our every-day needs, plus that of agriculture and industry, amount to some $4\frac{1}{2}$ to 5 million million gallons each year. This figure, though vast, is well within the estimated quantity (35 million million gallons) of water which is annually returned to the sea. There is therefore no danger in expanding our uses of water for hydro-electric schemes and the improvement of water supplies to rural areas; but locally there is an urgent need for controlling the amount of water drawn daily from boreholes, particularly near the sea. Many areas, such as Gravesend, are now polluted by salt water as a result of uncontrolled withdrawal of water from the chalk. Remedial measures in such cases can only be undertaken "as a public experiment designed for public and not individual profit." In his concluding remarks Dr. Bailey recommends authorities to examine the experiences of the U.S.A. before steps are taken to deal with the problem of underground water supplies.

Hydro-electric power. By Sir William Halcrow

In his review of the use of water-power in this country Sir William deals with the possibilities of using tidal movements for generating electricity. He briefly discusses the three main methods of exploiting this source of water power. Of these the basin system is the most promising. Simply, this involves constructing a barrage across an estuary with openings left in it to allow the water to flow into the enclosed area. When the tide is high the openings are closed, and as it falls the difference in the level of the impounded water and the sea below the barrage is used to drive turbines. He advances suggestions to compensate for the obvious variations of the power output, of which one is to pump water into a high-level reservoir when the turbines are at a maximum output, and then use this to keep the power plant going at high tides, or as required. Another method, which is at present in an experimental stage, is to use the surplus energy when the turbines are working at full capacity for heating large water tanks situated in towns "so that houses could be supplied with constant hot water in the same way as they are supplied with cold-water, gas or electricity."

ECONOMIC CONDITIONS IN FORMOSA

Much detailed information, collected from official sources, on the economic and social conditions in Formosa (Taiwan) is given in 'Formosa to-day,' by A. J. Grajdanzev, published by the Institute of Pacific Relations, 1942. Formosa was the first tropical colony of Japan, and developments under Japanese rule afford some clue to the methods and progress of Japanese expansion. It is clear first that Japanese immigration on any considerable scale has failed. Approximately 95 per cent. of the population are Chinese, who number 5·4

millions (including about 150,000 aborigines). There are about 310,000 Japanese, or just over 5 per cent. of the total, who are mainly engaged in administration, commerce, and industry. Despite several ambitious settlement schemes, the number of Japanese dependent on agriculture is about 8000 only. The population is therefore divided into two sharply defined sections, for it is estimated that nearly three-quarters of the Chinese derive their living from agriculture. Another difficult aspect of the situation is the rapid growth of this farming population, the rate of increase exceeding that of the Japanese. The increase amounts to about 130,000 a year, resulting in a demand for land which cannot be satisfied. Since 1904 it is estimated that the population has almost doubled, while the cultivated area has expanded by one-third only.

The principal crops are rice and sugar cane, which represent over two-thirds of the total production by value. Under Japanese rule, production has risen considerably, through the irrigation and double-cropping of rice-fields, the introduction of improved types of sugar cane, and a general increase in yields, though these have risen less than in Japan. Rice production has doubled in the last twenty-five years, and half is now exported to Japan. Over a rather longer period, the area under sugar cane has increased nearly four times, and the total output twelve times. This is largely due to the activities of large Japanese companies, who hold a monopoly of milling, and profit from the competition among the smaller growers. In other ways, *e.g.* through the terms of tenancies they exercise close control over production. Despite increased returns from this output it is probable that the share of the small farmers in the profits has declined. The type of rice demanded by the Japanese market, for example, requires greater expenditure on fertilizers, and rents have risen owing to the pressure of the rural population. The standard of living is certainly lower than in Japan. Much of the profit has gone to Japanese companies engaged in food industries, shipping, and commerce.

In industry there is a similar contrast between a small number of powerful corporations and small-scale and more primitive native producers. The rise in output is mainly the result of the growth in the food industry, particularly in the preparation of sugar from cane. Industrial production per head however is one-quarter only of that in Japan. In fact, by 1939 Formosa had become an agricultural appendage to Japan; four-fifths of its exports were agricultural raw materials or products manufactured from them, and nine-tenths of the total external trade was conducted with Japan. The balance of trade is markedly in favour of Japan; so that in addition to maintaining 300,000 Japanese and securing the requisite funds to turn the island into a powerful Japanese base, Japan also draws a profit of more than 100 million yen a year from the colony.

WELFARE IN THE COLONIAL EMPIRE

The principles underlying the social policies pursued in the Colonial Empire and the progress achieved in recent years are succinctly summarized by L. P. Muir in 'Welfare in the British Colonies' (R. Inst. of International Affaris, 5s). The disintegrating effect on traditional native life of Western economic practices and intellectual ideas is now generally recognized, and the necessity for combatting its major evils accepted. In its widest aspect the problem is the creation of social communities adjusted to the changed conditions so that they can fully utilize the natural resources of their environment, while preserving those elements of traditional life which promote social stability and cooperation. In some regions, such as the West Indies, the problem is complicated by fluctuations in world economy; in much of Africa the need is

to establish self-sufficing and well-balanced rural communities. The problem has therefore several aspects; education, labour, health, and technical instruction, besides social welfare as generally understood, require consideration. Cooperation between all the services responsible for these is essential, and throughout the essay emphasis is placed upon education as the link between them. Education had earlier been largely regarded as a means of escape from traditional life, and thus tended to create a westernized class, more or less trained on European lines, without prospect of adequate employment and isolated from their own people. The present policy aims therefore at providing education both for adults and children which is directly related to the needs of daily life, and at enlisting the cooperation of the peoples themselves, either as officials or as voluntary workers. The general method was outlined in the Colonial Office "Memorandum on mass education in African society," which, though referring specifically to Africa, is capable of wider application. A number of successful experiments in rural education and community councils are given by the author, but admittedly there is much yet to be done. These bodies can obviously perform useful work also in improving agricultural technique, health, and diet. One of the main effects of European expansion in Africa has been the temporary migration of great numbers of natives to industrial centres such as the Rhodesian copper belt, with the consequent dislocation of tribal life and the exposure of the migrants to unorganized and deleterious town life. Whether a permanent class of native industrial workers completely detached from the land should be created is apparently still unsettled. The efforts of the administrations have been directed to assisting the journeys of the migrants, supervising the conditions of labour, and raising the standard of diet and accommodation.

RECENT GEOGRAPHICAL APPOINTMENTS

In recent months a number of appointments to Chairs of Geography in British and Dominion Universities have been announced. Mr. G. H. T. Kimble has been appointed first Professor of Geography at McGill University, Montreal. Three of the appointments are consequent upon the retirement of the holders of chairs: Mr. Walter Fitzgerald, in succession to Professor H. J. Fleure, Manchester University; Dr. S. W. Wooldridge, in succession to Professor E. G. R. Taylor, Birkbeck College, University of London; and Dr. H. C. Darby, in succession to Professor P. M. Roxby, Liverpool University. At three Universities Chairs of Geography have been created for the Heads of Departments: for Dr. A. Austin Miller at Reading University; for Mr. A. V. Williamson at Leeds University; and for Mr. G. H. J. Daysh at King's College, Newcastle-upon-Tyne. Dr. L. R. Wager, who has done much to advance research in physical geography, has been appointed Professor of Geology at Durham University, in succession to Professor Arthur Holmes, now Regius Professor of Geology in the University of Edinburgh.

THE EUPHRATES VALLEY AND THE HABBANIYA SCHEME

The Government Press of 'Iraq has published the first volume of an account, in Arabic, of the Euphrates Valley and the Habbaniya Scheme, by Ahmed Sousa. The author states that his object is to bring irrigation to the notice of the inhabitants of 'Iraq, which up to this time has engaged the attention of foreigners rather than natives.

The first of the three sections consists of a detailed description of the course of the Euphrates from its source down to the Habbaniya Lake. The description is in part historical, drawing on classical and Arabic geographical sources, and

in part modern, including recent observations on the river and its tributaries. Special attention is devoted to the nilometers (*miqyas*) and the significance of the statistics derived from them, especially in planning river schemes to prevent periodic uncontrolled flooding and to assist irrigation.

The Habbaniya Lake is described in the second section together with Bahr al-Milh and the Abu Dibs Depression, and there is an account of the history of the Habbaniya Scheme from its start before the 1914–18 war up to the present. Constant reference is made to the work of Sir William Willcocks, part of whose 'From the Garden of Eden to the crossing of the Jordan' was published in Arabic at Baghdad in 1943.

Part three discusses the advantages which should result from the completion of the Habbaniya Scheme. These are the prevention of flooding by drainage of the surplus water from the Euphrates into the Habbaniya Lake, the increased volume of water available for irrigation during the dry summer months, and the control of malaria and other diseases. The effect on 'Iraq of plans for the upper reaches of the river, and of the Habbaniya Scheme on the lower reaches, are discussed. Other interesting paragraphs include a plan of settlement for the Balikh area of Syria. An appendix adds a full set of references to the discussion on the Habbaniya Scheme in the 'Iraq Chamber of Deputies and Notables.

Ahmed Sousa includes a bibliography of Arabic and English works on irrigation going back as far as 1919. In view of the difficulty of collecting bibliographical material on this subject, a list of the recent books or pamphlets quoted by Dr. Sousa may be useful; all of them were written after 1940:

J. D. Atkinson: 'Ramadi Intake.' Report on results of model experiments. Irrigation Directorate General. Baghdad, 1941. 'Irrigation in 'Iraq and Egypt.' Government Press, Baghdad, 1942.

G. Cardiacos. 'Abacs to be used for forecasting the peak levels in the rivers Euphrates and Tigris.' Baghdad, March 1943 (report).

H. Charles: 'La sédénterisation entre l'Euphrate et le Balik.' Beirut, 1942.

Ali Ghalib: 'Malaria,' and 'Malaria in 'Iraq.' Facts and Prospects in 'Iraq Series. Jerusalem, 1944.

A. P. Humble: 'Habbaniya flood relief and reservoir scheme memorandum.' Irrigation Directorate General, Baghdad, July 1943.

Subhi Mazlum: 'Le problème de l'eau en Syrie et au Liban.' Les Lettres Orientales, Beirut, 1942.

Ahmed Sousa: 'Irrigation in 'Iraq' (in Arabic). Baghdad, 1942. 'The results of irrigating 'Iraq' (in Arabic). Baghdad, 1942.

"Habbaniya flood relief and reservoir scheme." Note on the Warrar and Dhibban Channels. Irrigation Directorate General, Baghdad, 1944.

THE MINERAL WEALTH OF CHINA

In the October issues of the *Geographical Review* and *Foreign Affairs* there are papers to some extent complementary on the mineral wealth and resources of China. In the *Review* Mr. Kung-Ping Wang deals with the distribution and reserves of the resources, concentrating particularly on the non-ferrous metals. In *Foreign Affairs* Mr. C. H. Behre and Mr. Kung-Ping Wang consider the general economic position and possible future developments.

In general China has sufficient mineral resources to become an important industrial nation and to increase considerably her mining activities. A recent and conservative estimate of coal reserves is 246,000 million metric tons, though figures as large as 900,000 million metric tons have been suggested. This compares with an estimate of under 200,000 million metric tons for Great Britain. Prior to the Japanese war Chinese coal production was concentrated on the

eastern seaboard to meet the demand for bunkering, but, as a result of the war, production has greatly increased in the west and north, where the greatest reserves and the highest rank of coal are found.

The reserves of iron ore are suggested to be in the neighbourhood of 1,600 million metric tons, the greater part being in Manchuria. The iron smelting industry was largely situated in Manchuria and along the eastern seaboard. Although some of the furnaces have been moved to the west, over two-thirds of the productive capacity is now in Japanese hands.

Of the rarer minerals, tin, antimony, and tungsten are most important. China ranks fourth or fifth in world tin production, the chief mining areas being in Yunnan and 80–90 per cent. coming from Kokiu. Chinese antimony usually accounts for some 70–80 per cent. of world production, the chief centre is Hunan, but deposits are found over a wide area in south China. Before the present war China also dominated the tungsten market. The recent capture of Hengyang by the Japanese is serious, especially combined with the loss of the Burmese production, in view of the importance of tungsten to the armament industry.

Although the greater part of China has not been geologically surveyed in detail deposits of most minerals have already been found of which lead, zinc, copper, mercury, and the precious metals are already being mined. The extensive reserves of magnesite and bauxite in Manchuria are being exploited by the Japanese and will have increasing importance in the future.

Neither of the two papers sets out to give an account of the benefits gained by Japan or of the damage caused by the war to the eastern mining installations, but some picture can be formed. It is interesting to note the movement of the coal and iron industries dictated by the war towards the west, where the mineral reserves are centred and which in the long run should prove beneficial to Chinese industrialization. Corresponding transportation facilities are however essential for successful development.

DRAINAGE PATTERNS IN WESTERN QUEENSLAND

The development of drainage systems upon a very flat surface in monsoonal conditions is the subject of an interesting paper by Dr. F. W. Whitehouse in the *Australian Geographer* for June 1944. The area described is the great plains of Western Queensland, where the surface falls very slightly to the northern coast or towards Lake Eyre in the south. Upon this level surface which, as there is little underground percolation, has a maximum run-off, several complex systems of drainage channels, of a type apparently not recorded elsewhere, have developed to deal with the floods following the summer monsoons. The flood-water is accommodated in several ways, *e.g.* by intermittent deepening of the stream bed, forming water-holes, by widening of the area through the formation of meanders and reticulate streams, and by lateral pans which act as temporary reservoirs. No divides exist between the major streams. The particular pattern evolved depends largely upon the width of the flood plain.

Three types, found north of the slight divide in 21° S., are described by the author in some detail. On the salt flats of the north, which are flooded by salt and fresh water during the monsoons, true deltas are formed with widely meandering streams and unusual subsidiary drainage patterns in the salt-water area. On the inner lobes of the meanders are numerous straight channels radiating approximately from the common centres, and often truncated at their lower ends by silt levées. On the steppe lands, if the flood plain is relatively narrow, the streams divide into a regular network of channels, which cut up the flood plain into wide lozenges, and are later stabilized by the formation of

levées. On the level coastal plains of the Western Cape York Peninsula, a third type is characteristic. This area is subjected to seasonal flooding by the rivers, which divide into a large number of distributaries. Some of these rejoin the parent river lower down, but more often they flow into another river, so that all the main rivers are interlaced. In some of these compound streams, the main course swings across the subsidiary channels which continue independently. These distributaries commonly originate as levée streams: the floods spill over the levées during the wet season and form a complementary stream which in most cases does not rejoin the parent downstream but ultimately flows into another river. The paper is illustrated by several air photographs, which show clearly the intricate stream patterns evolved under these unusual conditions.

GEOGRAPHY SCHOLARSHIPS AT CAMBRIDGE

A conference took place in Cambridge on 27–29 July 1944 to consider the position of Geography in the scholarship schemes of the Cambridge colleges. At the present time only three men's colleges (St. John's, St. Catharine's, and Selwyn) offer entrance scholarships either for geography alone or for geography in combination with other subjects; while in the women's colleges the subject has the same treatment as any other, the number of awards depending upon the standard reached by the candidates. The Conference was attended by representatives of the colleges and other University bodies, the Local Examination Syndicate, the four secondary school associations, the Geographical Association, the Royal Geographical Society, and the Ministry of Education. Mr. Leonard Brooks and Professor Austin Miller represented the Society. The matters under discussion extended beyond the present and future scholarship facilities in Geography, but the following summary indicates the main conclusions regarding scholarships:

Having heard the evidence that many able boys are deterred from reading Geography beyond the School Certificate stage by the scarcity of Geography Scholarships at Oxford and Cambridge, the Conference urged the Colleges to grant more scholarships in Geography.

It was agreed that examinations for Geography Scholarships should harmonize with current education in the schools and should encourage both the specialist and those who have continued their education on broader lines.

The Conference considered that Geography is a valuable auxiliary subject for students of History, Classics, Modern Languages, and Natural Sciences, and that it could with advantage be included in Scholarship Examinations in those subjects. L. B.

GEOGRAPHICAL AND BOTANICAL EXPLORATION OF CENTRAL AND WESTERN NORTH AMERICA

An important biography of John Torrey, recently published by the Princeton University Press, emphasizes the unknown nature of the North American West a century ago, and shows how its explorers, whether or not they were accompanied by botanists, having been brought up in a period of scientific awakening, made extensive collections of plants. John Torrey was born in 1796 in New York, and died in 1873. Though a physician by training and largely a chemist by profession, he was by preference a botanist. He was not so much an active explorer as a scholar who advised the expeditions as they prepared for work in the field, and worked up the results on their return. This last he did with scrupulous care and devotion, publishing the results in numerous books and important papers. His descriptions of new species are particularly vivid, standing as models to this day.

Torrey knew and corresponded with most of the American botanical and other explorers of his time, such as Thomas Drummond, Sir William Hooker, and Colonel Frémont, so that this story of his life is punctuated with their names and contains long and revealing extracts from their letters.

Torrey lived in a vigorous phase of American history, and so his biography, which concentrates on the aspect of a pioneer in taxonomic and phytogeographical research, should prove valuable to students, botanical or otherwise, of the period or region. Torrey's name is commemorated in a remarkable genus belonging to the Coniferae and in numerous species of flowering plants, in a peak in the Rocky Mountains, and in many other ways such as the Torrey Botanical Club; but his influence has spread much wider. Even apart from his writings the collections he accumulated went far towards starting what are now two of the greatest herbaria in the world. N. P.

OBITUARY

Mrs. Laetitia Carolina Peyton-Jones, who died in Bath on October 8 at the age of ninety-six, had been a Fellow of the Society since 1919. She was born in Launceston, Van Dieman's Land, where her father was Colonial Surgeon. His friendship with Sir John and Lady Franklin stimulated her interest in exploration which was always maintained. She accompanied her husband on journeys in Victoria in connection with railway surveys, and had travelled in China. In her later years she frequently attended the meetings of the Society.

ELECTIONS

The following have been elected Fellows of the Society

On August 8: Wilfred Asten; George W. Morris; Lieut. Verdun Alexander Middleton Rosie, R.E.; Mrs. Daisy Taylor; Lieut.-Colonel D. E. O. Thackwell, R.E.; Merle John Laurence Trenchard; Edgar Arthur Warren